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ASA subsystems, as described in Chapter 2, and as depicted in Figure 3.0-1, consist of surveillance transmit and receive functions, Surveillance Transmit Processing (STP), Airborne Surveillance and Separation Assurance Processing (ASSAP), and the Cockpit Display of Traffic Information (CDTI). In addition, ASA interfaces with several external subsystems, including navigation, and potentially, the FMS and flight controls.

This chapter details interface requirements between ASA subsystems, and details specific subsystem requirements. This chapter also documents assumptions on the performance of subsystems external to ASA.

The chapter is structured so that ASA transmit functions and ASA receive functions are treated separately. Both transmit and receive function requirements are broken into one section that describes interfaces and a section that describes functional and performance requirements.

ASA requires interfaces to and from many existing and envisioned on-board avionics systems. All interface requirements depicted in Figure 3.0-1 relevant to ASA are detailed in the descriptions and tables below.

Note that Figure 3.0-1 identifies system interfaces that are outside of ASA. It is also noted in the figure that some interfaces in the figure from ASA are not specified in this version of the ASA MASPS, but will be specified in later versions. Some of these interfaces are described in the “probe” application analyses as potential future requirements.

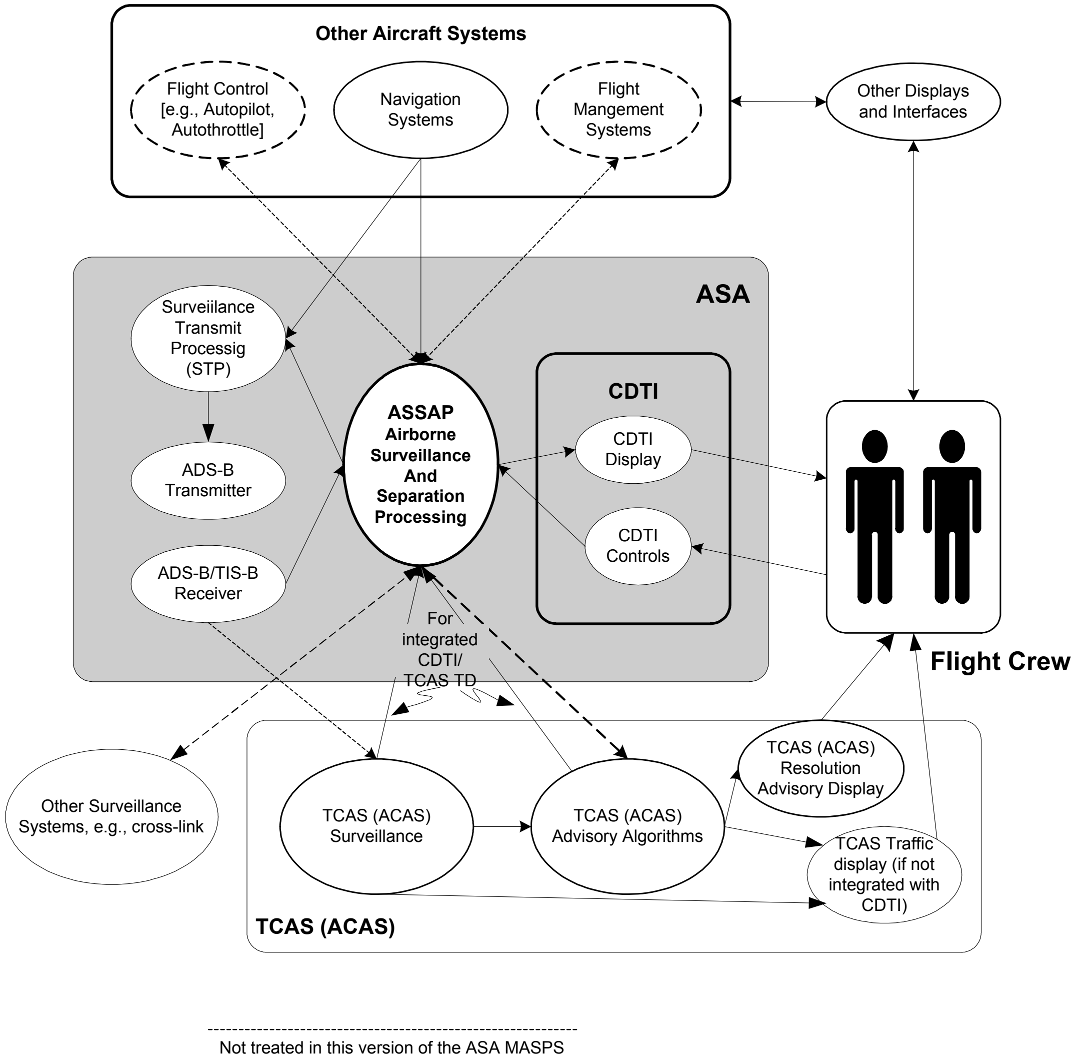


Figure 3.0-1: ASA Subsystems And Their Interfaces

3.1 ASA Transmitting Participant Subsystems

The ASA Transmit Subsystem, represented by interfaces B to D in Figure 3-1, **shall** consist of a Surveillance Transmit Processing subsystem (STP) and an ADS-B Transmitting subsystem. These subsystems take data from on-board aircraft sensors and systems, convert to defined ADS-B data standards and provide for broadcast of this ADS-B data to other aircraft and ground users to support surveillance applications.

Note: *The ADS-B data standards are defined in DO-242A ADS-B MASPS document. The ADS-B MASPS does not define the on-board data conversion processing requirements, but only data definition and format requirements. In some ADS-B equipment architectures, the ADS-B data sources may directly interface with the ADS-B transmitting equipment where both functions are provided and not require external pre-processing of surveillance data.*

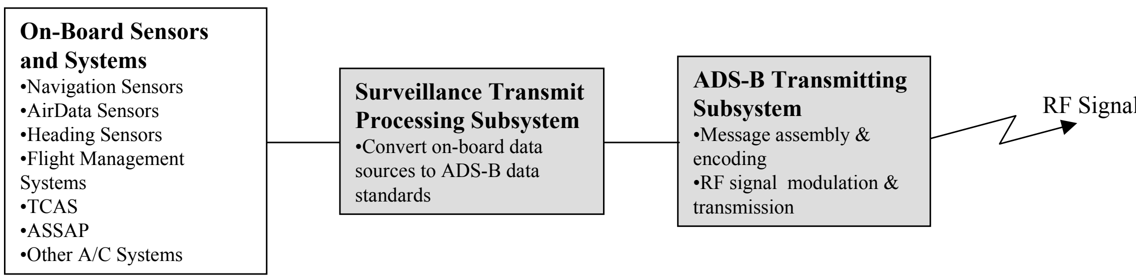


Figure 3.1-1: ASA Transmit Subsystems

3.1.1 Surveillance Transmit Processing (STP) Subsystem Requirements

The Surveillance Transmit Processing (STP) subsystem, represented by interfaces B to C in Figure 3-1, **shall** provide for the conversion and formatting of surveillance data obtained from aircraft sensors and systems into the standardized ADS-B formats that are broadcast to other users. Because there will not be uniformity in the data interfaces of avionics equipment on-board ASA equipped aircraft, the source data may require conversion to comply with the standard ADS-B data definitions. Some of the surveillance information elements that require specific processing are:

- Determination of Transmit Service Level
- Determination of own aircraft ASA Level
- Determination of navigation data quality
- Determination of common position reference
- Management of multiple navigation data sources
- Determination of air/ground state
- Determination of flight path intent (future function)

Note: *Additional items requiring specific processing to achieve a standardized information exchange definition may be added in the future as they are identified. One item to be added in future versions of this MASPS is the determination of aircraft intent.*

3.1.1.1 ASA Transmit Subsystem Service Levels

The "service level" broadcast by the on-board ASA Transmit subsystem indicates the capabilities of the transmitted surveillance information to support of other user surveillance applications. The service level value sent identifies the quality of both the surveillance equipment on-board the aircraft and the surveillance information transmitted. Service levels "group" sets of requirements for surveillance equipment and transmitted surveillance information. Service levels are hierarchical in that higher service levels announce that a participant supports the capabilities of all lower service levels.

All ASA Transmit subsystem equipped aircraft **shall** assess and transmit their service level. The service level **shall** be assessed dynamically, so that changes in capabilities are announced, especially when the on-board equipment no longer qualifies for its previously announced service level.

Service level conveys quality characteristics of the on-board ASA Transmit subsystem that are not specifically communicated in other ADS-B messages, such as the actual NAC, NIC, and SIL values for position information. Service Level **shall** address the following ASA Transmit subsystem characteristics:

- Minimum ASA equipment integrity (transmit & surveillance eqpmt?)
- Minimum ASA equipment availability
- Maximum data latency requirement for specified information elements
- Minimum NIC for position information (normal operations)
- Minimum SIL for position information (normal operations)
- Minimum transmitted information requirements (these are identified in §3.1.3)
- Minimum ASA continuity of service

The ASA Transmit subsystem service levels **shall** be determined as defined in Table 3.1-1.

Table 3.1-1: ASA Transmit Subsystem Service Levels

Characteristic	Service Level			
	1	2	3	4
Minimum ASA Equipment Integrity	$>10^{-3}$ per hour	$\leq 10^{-3}$ per hour	$\leq 10^{-5}$ per hour	$\leq 10^{-7}$ per hour
Minimum ASA Equipment Availability	>0.95	>0.9995	>0.9995	>0.9995
Maximum Uncompensated Data Latency	<1.2 s 95%	<1.2 s 95%	<0.4 s 95%	<0.4 s 95%
Minimum NIC	≥7	≥8	≥9	≥9
Minimum SIL	$\leq 10^{-3}$ per hour	$\leq 10^{-5}$ per hour	$\leq 10^{-5}$ per hour	$\leq 10^{-7}$ per hour
Minimum ASA Service Continuity	$<10^{-3}$ per hour	$\geq 10^{-3}$ per hour	$\geq 10^{-5}$ per hour	$\geq 10^{-7}$ per hour

Note: Above strawman table values are subject to change and have not been reviewed by WG4.

The ASA Transmit subsystem **shall** assess that all of the requirements associated with a specific service level are met before transmitting that service level. When specified requirements are no longer met, the change in service level **shall** be transmitted within **TBD** seconds. The elements associated with Service Level are defined by the following.

3.1.1.1.1 Minimum ASA Equipment Integrity

The minimum ASA equipment integrity **shall** be supported for a specific Service Level. The ASA equipment integrity is the probability (per operating hour) of an undetected failure of the ASA transmit function that results in potentially erroneous information being transmitted. The probability includes the failures of the ASA Transmit subsystem equipment but does not include the external surveillance information source sensors and systems.

Note: The navigation position source equipment integrity in included in the SIL value that is transmitted.

3.1.1.1.2 Minimum ASA Equipment Availability

The minimum ASA equipment operational availability **shall** be supported for a specific Service Level.

3.1.1.1.3 Maximum Data Latency

The maximum uncompensated latency of the transmitted dynamic aircraft state information that **shall** be supported for a specific Service Level.

Note: *The latency is specified at the ADS-B transmit antenna and does not include signal-n-space delays or any participant's receive latency contributions that are observed by applications.*

3.1.1.1.4 Minimum NIC

The minimum NIC value for the navigation data source that **shall** be supported for a specific Service Level.

Note: *When an alternate navigation data source is selected, e.g. RNAV or INS, due to a failure of the primary source, the associated NIC for this source may require the reporting of a lower Service Level.*

3.1.1.1.5 Minimum SIL

The minimum SIL value for the navigation data source that **shall** be supported for a specific Service Level.

Note: *When an alternate navigation data source is selected, e.g. RNAV or INS, due to a failure of the primary source, the associated SIL for this source may require the reporting of a lower Service Level.*

3.1.1.1.6 Minimum Transmit Information

The minimum ADS-B information that **shall** be transmitted for a specific Service Level is identified in Section 3.1.3.

3.1.1.1.7 Minimum ASA Service Continuity

The minimum ASA continuity of service probability (per operational hour) **shall** be supported for a specific Service Level. The service continuity is the probability that the ASA Transmit function will not continue to provide surveillance information. The probability includes: (1) ASA Transmit subsystem equipment and the surveillance information source equipment failure rates and (2) position source signal-in-space affects that can result in loss of valid position information.

Note: *Continuity is specified at the ADS-B transmit antenna and does not include any signal-in-space affects or the reliability of the participant's receive side equipment.*

3.1.1.2 ASA ASA Level

The "ASA Level" broadcast by the ASA Transmit subsystem indicates the surveillance applications that the on-board ASA system is capable of supporting. These are applications that are installed and certified for operational usage, however, the reported ASA Level does not necessarily indicate which application is currently selected and in use by the flight crew. The surveillance applications are grouped into sets of applications that support equipage levels and operational needs of the intended users. ADS-B equipment **shall** broadcast one of the following ASA Levels that are defined in Section 2.???.

3.1.1.3 Navigation Data Processing

The navigation equipment available to support airborne surveillance systems will not be uniform among all ASA installations, therefore, there is a need to convert the data from navigation sources into the standard ADS-B data formats. Some of the required information elements will need to be determined based on the certified performance of the navigation sensor since appropriate data parameters are not output from the equipment. When multiple navigation sources are available to the ASA equipment, the use of the best available source will need to be assessed and selected. The following identifies the areas that require specific processing to provide the required surveillance data to the ADS-B Transmitting subsystem.

- Determination of navigation data quality
- Determination of accuracy (NAC_p, NAC_v
- Determination of integrity radius of containment (NIC)
- Determination of navigation source integrity (SIL)
- Compensation for data latency
- Determination of common position reference point
- Management of multiple navigation data sources

3.1.1.3.1 Determination of Navigation Data Quality

The navigation data sources available to support ASA will not be uniform across all A/V, therefore, the appropriate values that define the quality of the navigation data that is transmitted will need to be determined. Some sources may output data parameters that meet the required ADS-B data definitions, however, other sources may require the available data outputs to be converted, interpreted, or formatted. In some cases, data will not be output from a source navigation sensor or system, therefore the values reported may need to be based on equipment certification values. The following sections define the criteria for determining the navigation data quality.

3.1.1.3.1.1 Determination of NAC_p Values

The Navigation Accuracy Category for Position (NAC_p) to be associated with the transmitted geometric position information **shall** be obtained from the source providing the position information. When VEPU or VFOM values are not available from a position source, the geometric vertical position **shall** be reported as invalid. The reported values of NAC_p **shall** be those identified in §3.1.3.9.

Note: For high NAC_p values, when the reported position is not corrected to that of the A/V position reference point and the antenna of the navigation sensor is not located in very close proximity to the A/V position reference point, the resulting position error may require the downgrade of the reported NAC_p value.

3.1.1.3.1.2 Determination of NAC_v Values

The Navigation Accuracy Category for Velocity (NAC_v) to be associated with the transmitted geometric velocity information **shall** be obtained from the source providing the velocity information. When accuracy values for vertical velocity are not available from a velocity source, the geometric vertical velocity **shall** be reported as invalid. The reported values of NAC_v **shall** be those identified in §3.1.3.10.

3.1.1.3.1.3 Determination of NIC Values

The Navigation Integrity Category (NIC) to be associated with the transmitted geometric position information **shall** be obtained from the source providing the position information. The reported values of NIC **shall** be those identified in §3.1.3.8. When VIL or VPL values are not available from a position source, the geometric vertical position **shall** be reported as invalid.

3.1.1.3.1.4 Determination of SIL Values

The Surveillance Integrity Level (SIL) defines the probability for the horizontal integrity containment radius or vertical containment limit used in the NIC parameter being exceeded, without detection, including the effects of the airborne navigation equipment condition, which airborne navigation equipment is in use, and which external signals are used by the navigation source. The reported values of NIC **shall** be those identified in §3.1.3.11

SIL **shall** be defined as:

> "Probability of NIC exceedance without detection + Probability of navigation equipment failures affecting navigation data outputs without detection"

SIL is assumed to be a static value that is determined for each candidate on-board navigation data source equipment. When an alternate navigation data source is selected for ASA, the reported SIL **shall** become the value for the new source that is selected.

3.1.1.3.1.5 Determination of Measurement Time of Applicability

The aircraft state data transmitted **shall** be adjusted to a common time of applicability if necessary to meet the data latency requirements specified in section ???.

<u>Note</u>: *The time of applicability may be the time of transmission when receiving systems provide time stamping for determination of time of applicability.*

3.1.1.3.2 Determination of Common Position Reference Point

The common surveillance *position reference point* of an A/V **shall** be defined as the center of a rectangle (the "defining rectangle for position reference point") that has the following properties:

a. The defining rectangle for position reference point **shall** have length and width code as defined in Table 3.1-5 below.

b. The defining rectangle for position reference point **shall** be aligned parallel to the A/V's heading.

c. The ADS-B position reference point (the center of the defining rectangle for position reference point) **shall** lie along the axis of symmetry of the A/V. (For an asymmetrical A/V, the center of the rectangle should lie midway between the maximum port and starboard extremities of the A/V.)

d. The forward extremity of the A/V **shall** just touch the forward end of the defining rectangle for position reference point.

Table 3.1-5: Dimensions of Defining Rectangle for Position Reference Point

A/V - L/W Code	Defining Rectangle Dimensions	
	Length	Width
0	15 m	11.5 m
1		23 m
2	25 m	28.5 m
3		34 m
4	35 m	33 m
5		38 m
6	45 m	39.5 m
7		45 m
8	55 m	45 m
9		52 m
10	65 m	59.5 m
11		67 m
12	75 m	72.5 m
13		80 m
14	85 m	80 m
15		90 m

Note: *The lengths and widths given are least upper bounds for the possible lengths and widths of an aircraft. An exception, however, is made for the largest length and width codes, since there is no upper bound for the size of an aircraft that broadcasts those largest length and width codes.*

Figure 3.1-2 illustrates the location of the ADS-B reference point, for an example aircraft of length 31 m and width 29m. Such an aircraft will have length code 4 L < 35 m and W < 33m. The ADS-B position reference point is then the center of a rectangle that is 35 m long and 33 m wide and positioned as given in the requirements just stated.

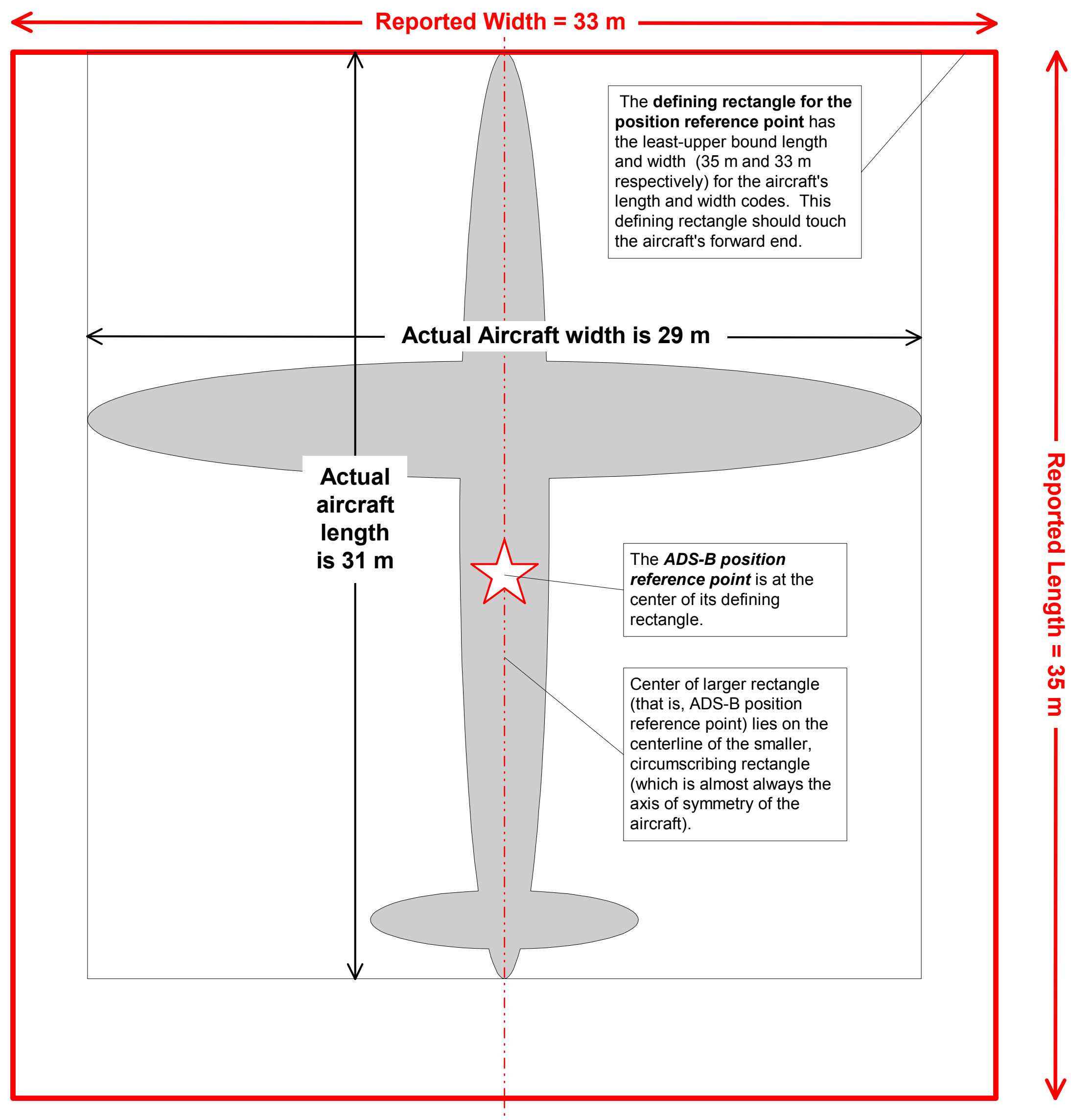


Figure 3.1-2: Position Reference Point Definition.

3.1.1.3.3 Management of Navigation Data Sources

It is assumed that the majority of ASA installations will be equipped with GNSS as their primary geometric position and velocity data source. Less capable navigation systems, such as RNAV and INS, will be used primarily as back-up sources. As such, the requirements for the selection and management of multiple navigations sources will need to be specified. The following requirements apply.

1. The navigation data source **shall** be capable of providing geometric position and velocity data suitable for surveillance based applications.

2. The navigation data **shall** include the following:

   - Own vehicle horizontal position in latitude and longitude

- Own vehicle velocity (true north & east). (Ground speed/ground track may be used if velocity $_{north/east}$ is not available. Ground track requires a discrete to indicate true/mag reference.)
- Own vehicle geometric height above ellipsoid surface, if available.
- Position and velocity validity flags

3. The navigation data **shall** be accompanied with accuracy and integrity metrics for determination of Navigation Integrity Category (NIC) and Navigation Accuracy Category (NAC_P for position and NAC_V for velocity) of the data.

4. There **shall** be a means to determine the SIL value for the navigation data source.

5. When a navigation data source fails, the source selection **shall** follow this priority order for available sources. When there are multiple sources of the same source type, these **shall** be selected prior to a lower navigation data source.

   - GNSS
   - RNAV
   - INS

Ed Note: this is an initial priority list – need input from the integrity subgroup.

A navigation data source **shall** be declared failed when the position validity indicates Failed state.

The switch over from a failed data source to another source **shall** occur within TBD seconds.

3.1.1.4 Air/Ground Assessment Processing

A transmitting participant's air/ground state **shall** have the following possible values:

- "Known to be airborne,"
- "Known to be on the surface"
- "Uncertain whether airborne or on the surface"

A transmitting ADS-B participant **shall** apply the following tests to determine its air/ground state:

6. If a transmitting ADS-B participant is *not* equipped with a means, such as a weight-on-wheels switch, to determine whether it is airborne or on the surface, and that participant's emitter category is one of the following, then it **shall** set its air/ground state to "known to be airborne":

   - Light Aircraft
   - Glider or Sailplane
   - Lighter Than Air
   - Unmanned Aerial Vehicle

- Ultralight, Hang Glider, or Paraglider
- Parachutist or Skydiver
- Point Obstacle
- Cluster Obstacle
- Line Obstacle

7. If a transmitting ADS-B participant is ***not*** equipped with a means, such as a weight-on-wheels switch, to determine whether it is airborne or on the surface, and that participant's emitter category is one of the following, then that participant **shall** set its air/ground state to "known to be on the surface" :

    - Surface Vehicle – Emergency
    - Surface Vehicle – Service

8. If a transmitting ADS-B participant is ***not*** equipped with a means, such as a weight-on-wheels switch, to determine whether it is airborne or on the surface, and that participant's emitter category is "rotorcraft," then that participant **shall** set its air/ground state to "uncertain whether airborne or on the surface."

9. If a transmitting ADS-B participant is ***not*** equipped with a means, such as a weight-on-wheels switch, to determine whether it is airborne or on the surface, and its ADS-B emitter category is not one of those listed under tests 1, 2, and 3 above, then that participant's ground speed (GS), airspeed (AS) and radio height (RH) **shall** be examined, provided that some or all of those three parameters are available to the transmitting ADS-B subsystem. If GS < 100 knots, or AS < 100 knots, or RH < 100 feet, then the transmitting ADS-B participant **shall** set its Air/Ground state to "known to be on the surface."

10. If a transmitting ADS-B participant ***is*** equipped with a means, such as a weight-on-wheels switch, to determine automatically whether it is airborne or on the surface, and that automatic means indicates that the participant is airborne, then that participant **shall** set its air/ground state to "known to be airborne."

11. If a transmitting ADS-B participant ***is*** equipped with a means, such as a weight-on-wheels switch, to determine automatically whether it is airborne or on the surface, and that automatic means indicates that the participant is on the surface, then the following additional tests **shall** be performed to validate the "on-the-surface" condition:

a. If the participant's ADS-B emitter category is any of the following:
   "Small Aircraft" or
   "Medium Aircraft" or
   "High-Wake-Vortex Large Aircraft" or
   "Heavy Aircraft" or
   "Highly Maneuverable Aircraft" or
   "Space or Trans-atmospheric Vehicle"

   and one or more of the following parameters is available to the transmitting ADS-B system:
   Ground Speed (GS) or
   Airspeed (AS) or
   Radio height from radio altimeter (RH)

   and any of the following conditions is true:
   GS > 100 knots or
   AS > 100 knots or
   RH > 100 ft,

   then the participant **shall** set its Air/Ground state to "known to be airborne."

b. Otherwise, the participant **shall** set its Air/Ground state to "known to be on the surface."

3.1.1.5 (Reserved) Intent Data Processing

In future versions of this MASPS, the requirements for intent data processing will be defined.

3.1.2 ADS-B Transmitting Subsystem Requirements

The ADS-B Transmitting subsystem, represented by interfaces C-D in Figure 3-1, works in concert with other aircraft or ground systems ADS-B Receiving subsystems. The ADS-B MASPS (DO-242) and its revisions **shall** specify transmit requirements such that they are broadcast link media independent, to the extent possible, and to allow flexibility in the manner that messages are transmitted and received to create ADS-B surveillance reports that are provided to ASA Applications. The transmitting ADS-B subsystem on the transmitting aircraft and the ADS-B Receiving subsystem on a receiving aircraft in combination need to meet requirements for data reception reliability, reception range, and update rate requirements in the expected operational environments, as specified in section XX.

ADS-B Transmitting subsystem functional capabilities include: 1) accept source data inputs, 2) assemble and encode the required ADS-B messages, 3) broadcast transmit the messages, 4) monitor for proper operation, and 5) provide notification of transmit system status.

[What other general ADS-B transmitting subsystem requirements should be addressed here?]

3.1.3 ASA Transmit Subsystem Interface Requirements

The ASA Transmit subsystem requires interfaces to many existing and envisioned on-board avionics system and sensors for the surveillance information to be broadcast. The range of aircraft types and models that may be equipped with an ASA Transmit subsystem result in a wide variation in avionics systems and sensors providing surveillance data. Not all aircraft will be able to provide all surveillance data elements. The following is a non-inclusive list of candidate surveillance data sources.

- GNSS sensors (list RTCA MOPS)
- RNAV systems (list RTCA MOPS)
- Inertial navigation systems
- Air data systems
- Heading reference systems
- Flight management systems
- Auto-flight systems
- Flight ID sources
- TCAS systems
- Aircraft state equipment, e.g. Weight-on-wheels

Note: *This MASPS addresses the surveillance information to be extracted from source avionics systems. The integration of ASA Transmit subsystem equipment into a candidate aircraft will establish the necessary physical interfaces, data conversions, and data formatting required. This is to be addressed by lower level MOPS documents.*

The following tables identify the surveillance data elements to be broadcast. The source equipment, in general terms, will be identified. In some cases, the fundamental source may be the from the Surveillance Transmit Processing subsystem for uniquely computed information elements. These items are identified in the paragraph (§3.1.2) above. The surveillance information required to be transmitted by ASA Transmit subsystem that is reporting a specific Service Level are indicated by "●". Other information elements that are "desired" are indicated by "d".

Table 3.1-6: ASA Transmit Subsystem Information Elements

Information Category	Information Element	Source	Service Level 1	Service Level 2	Service Level 3	Service Level 4	Notes
A/V Identification	Call Sign	A/V System	d	●	●	●	
	A/V Address & Address Qualifier	A/V System	●	●	●	●	
	A/V Category	STP	●	●	●	●	
	A/V Length and Width Code	STP	●	●	●	●	1
Navigation	Horizontal Position	GNSS, RNAV, INS	●	●	●	●	3
	Horizontal Position Valid	GNSS, RNAV, INS	●	●	●	●	
	Position Reference Point	STP					4
	NAC_p	STP	●	●	●	●	
	Horizontal Velocity	GNSS, RNAV, INS	●	●	●	●	3
	Horizontal Velocity Valid	GNSS, RNAV, INS	●	●	●	●	
	NAC_v	STP	●	●	●	●	
	Geometric Altitude	GNSS, RNAV, INS	●	●	●	●	3
	Geometric Altitude Valid	GNSS, RNAV, INS	●	●	●	●	
	Geometric Altitude Rate	GNSS, RNAV, INS	●	●	●	●	2, 3
	Geometric Altitude Rate Valid	GNSS, RNAV, INS	●	●	●	●	2
	NIC	STP	●	●	●	●	
	SIL	STP	●	●	●	●	
Air Data	Barometric Altitude	Air Data	●	●	●	●	3
	Barometric Altitude Valid	Air Data	●	●	●	●	
	BAQ	STP	●	●	●	●	
	NIC_{baro}	STP	●	●	●	●	
	Barometric Vertical Rate	Air Data	●	●	●	●	2
	Barometric Vertical Rate Valid	Air Data	●	●	●	●	2
Heading	Heading (True or Magnetic)	Heading	d	●	●	●	5
	Heading Valid	Heading	d	●	●	●	5
Aircraft State	Air/Ground State	STP	d	●	●	●	
ASA Equipment	Service Level	STP	●	●	●	●	
	ASA Level	STP	●	●	●	●	
	Capability Identification	STP	●	●	●	●	
Operating State	Operational Mode Parameters	STP	●	●	●	●	

• = Required; d = desired

<u>*Notes for Table 3.1-6*</u>:

1. *To be transmitted while A/V is know to be on the surface when A/V is of Length and Width Code of 2 or greater.*

2. *At least one of the two types of vertical rate (barometric or geometric) is to be broadcast. The type of vertical rate provided shall be indicated.*

3. *Each of these information elements is to be translated to a common time of applicability (TOA) prior to broadcast. The TOA value does not need to be transmitted if it can be determined by a receiving participant with a latency no greater than **TBD**.*

4. *The Position Reference Point is not a broadcast information element. It is used to translate, when required, the horizontal position from a navigation source to a standard A/V reference location prior to broadcast.*

5. *Heading is required while operating on the airport surface for aircraft with A/V Length and Width codes of 2 or greater.*

The ASA Transmit subsystem **shall** be capable of transmitting messages containing the surveillance information specified in the following subsections. The parameter range and resolution will be specified where appropriate.

3.1.3.1 A/V Identification

The basic identification information to be conveyed **shall** include the following elements:

- Call Sign
- A/V Address and Address Qualifier
- A/V Category
- A/V Length and Width Codes

3.1.3.1.1 Call Sign

The ASA Transmit subsystem **shall** convey an aircraft call sign of up to 8 alphanumeric characters in length.

3.1.3.1.2 A/V Address and Address Qualifier

The ASA Transmit subsystem **shall** transmit a locally unique address that enables a user to:

a. correlate all messages transmitted regarding the A/V, and
b. differentiate the A/V from other A/Vs in the operational domain.

3.1.3.1.2.1 A/V Address

The ASA Transmit subsystem **shall** transmit either the ICAO 24-bit addressed assigned to the A/V or another kind of address that is unique within the operational domain, as determined by the A/V Address Qualifier.

3.1.3.1.2.2 A/V Address Qualifier

The A/V Address Qualifier **shall** be used to describe whether or not the A/V Address contains the 24-bit ICAO address for the A/V or another kind of address.

Note: *Not all A/V are assigned ICAO addresses.*

3.1.3.1.3 A/V category

The ASA Transmit subsystem **shall** transmit an A/V Category code. Category describes the type of A/V of the transmitter to other users. The A/V Category transmitted **shall** be one of the following A/V types:

- Light (ICAO) - 7,000 kg (15,500 lbs) or less
- Small aircraft – 7,000 kg to 34,000 kg (15,500 lbs to 75,000 lbs)
- Large aircraft – 34,000 kg to 136,000 kg (75,000 lbs to 300,00 lbs)
- High vortex large (aircraft such as B-757)
- Heavy aircraft (ICAO) - 136,000 kg (300,000 lbs) or more
- Highly maneuverable (> 5g acceleration capability) and high speed (> 400 knots cruise)
- Rotorcraft
- Glider/Sailplane
- Lighter-than-air
- Unmanned Aerial vehicle
- Space/Trans-atmospheric vehicle
- Ultralight / Hang glider / Paraglider
- Parachutist/Skydiver
- Surface Vehicle - emergency vehicle
- Surface Vehicle - service vehicle
- Point obstacle (includes tethered balloons)
- Cluster obstacle
- Line obstacle

Notes:

1. *ICAO Medium aircraft – 7,000 to 136,000 kg (15,500 to 300,000 lbs) can be represented as either small or large aircraft as defined above.*
2. *Obstacles can be either fixed or movable. Movable obstacles would require a position source.*
3. *Weights given for determining participant categories are maximum gross weights, not operating weights.*

3.1.3.1.4 A/V Length and Width Codes

The ASA Transmit subsystem **shall** transmit codes that identify the A/V length and width, per Table 3.1-5 in section 3.1.1.3.2, when the A/V code is 2 or more and the A/V is known to be on the surface. The A/V length and width codes describe the amount of space that an aircraft or ground vehicle occupies.

3.1.3.2 Horizontal Position

The horizontal position of the A/V **shall** be transmitted in a form that can be translated, without loss in accuracy and integrity for the reported NAC_p and NIC codes, into latitude and longitude referenced to WGS-84 ellipsoid. Horizontal position communicated **shall** support the full range of possible latitudes (-90° to +90°) and longitudes (-180° to +180°). The validity of the horizontal position information **shall** be transmitted.

Horizontal position **shall** be communicated and reported with a resolution sufficiently fine that it does not compromise the accuracy reported in the NAC_P code.

Note: *It is likely that future surface movement and runway inclusion applications will require high NAC_p values. To obtain those high values, it may be necessary to correct the reported position to that of the A/V position reference point if the antenna of the navigation sensor is not located in very close proximity to the A/V position reference point.*

3.1.3.3 Position Reference Point

The nominal location of a transmitting A/V – the surveillance position that is reported to user applications in state information about that A/V – is the location of the A/V's *Position Reference Point,* as defined in section 3.1.1.3.2. The transmitted ADS-B position **shall** be corrected to this reference position when necessary to achieve the reported accuracy in NAC_p value. When the transmitted position is not corrected to the *Position Reference Point*, the resulting error in position **shall** be included in the NAC_p value that is reported. The *Position Reference Point* is not required to be transmitted to other participants.

3.1.3.4 Horizontal Velocity

The horizontal velocity of the A/V **shall** be transmitted in north-south and east-west velocity components relative to the WGS-84 coordinate system. The validity of the horizontal velocity information **shall** be transmitted. Horizontal velocity **shall** be provided with a range to accommodate speed of up to 4000 knots for airborne participants and up to 250 knots for surface participants.

Horizontal velocity **shall** be communicated and reported with a resolution sufficiently fine that it does not compromise the accuracy reported in the NAC_V code.

3.1.3.5 Altitude

Both barometric pressure altitude and geometric altitude (height above the WG84 ellipsoid) **shall** be transmitted, if available to the ASA Transmit subsystem. When an A/V is operating on the airport surface and is indicating that it is on the surface, the transmission of altitude is not required. Altitude **shall** be provided with a range from –1,000 ft up to +100,000 ft. For fixed or movable obstacles, the altitude of the highest point should be reported.

3.1.3.5.1 Barometric Altitude

The barometric altitude of the A/V **shall** be transmitted referenced to standard temperature and pressure. The validity of the barometric altitude information **shall** be transmitted.

If a pressure altitude source with 25-foot or better resolution is available to the ADS-B transmitting subsystem, then pressure altitude from that source **shall** be communicated and reported with 25-foot or finer resolution. Otherwise, if a pressure altitude source with 100-foot or better resolution is available, pressure altitude from that source **shall** be communicated and reported with 100-foot or finer resolution.

3.1.3.5.2 Geometric Altitude

The geometric altitude of the A/V **shall** be transmitted as the shortest distance from the current aircraft position to the surface of the WGS-84 ellipsoid. Geometric altitude **shall** be indicated as positive for positions above the WGS-84 ellipsoid surface, and negative for positions below that surface. The validity of the geometric altitude information **shall** be transmitted.

Geometric altitude **shall** be communicated and reported with a resolution sufficiently fine that it does not compromise the vertical accuracy reported in the NAC_P code.

3.1.3.6 Vertical Rate

A/Vs that are a not fixed or movable obstacle and that are not known to be on the airport surface **shall** provide vertical rate. Vertical Rate **shall** be designated as climbing or descending and **shall** be reported up to 32,000 feet per minute (fpm). The validity of the vertical rate information **shall** be transmitted.

Barometric altitude rate is defined as the current rate of change of barometric altitude. Likewise, geometric altitude rate is the rate of change of geometric altitude. At least one of the two types of vertical rate (barometric and geometric) **shall** be transmitted. An indication of which type of altitude rate is being transmitted **shall** be provided.

Geometric vertical rate **shall** be communicated and reported with a resolution sufficiently fine that it does not compromise the accuracy reported in the NAC_V code.

3.1.3.7 Heading

Heading **shall** indicate the orientation of an A/V, that is, the direction in which the nose of the aircraft is pointing. Heading **shall** be indicated as an angle measured clockwise from true north or magnetic north. An indication **shall** be provided as to whether the heading is measured from true north or magnetic north. The heading transmitted **shall** support the full range of possible headings (full circle from 0° to nearly 360°). The heading of surface participants **shall** be communicated with a resolution of 6° of arc or finer. The validity of the heading information **shall** be transmitted.

Note: *Heading is required for surface applications only.*

3.1.3.8 Navigation Integrity Category (NIC)

The Navigation Integrity Category (NIC) is transmitted so that surveillance applications may determine whether the transmitted position has an acceptable level of integrity for the intended use by a receiving system. The NIC parameter specifies an integrity containment radius, R_C for the transmitted position.

Table 3.1-7 defines the navigation integrity categories that transmitting ADS-B participants **shall** use to describe the integrity containment radius, R_C, associated with the horizontal position information in ADS-B messages.

Table 3.1-7: Navigation Integrity Categories (NIC).

NIC (Note 1)	Horizontal and Vertical Containment Bounds	Comment	Notes
0	$R_C \geq$ 37.04 km (20 NM)	Unknown Position Integrity	
1	$R_C <$ 37.04 km (20 NM)	RNP-10 containment radius	4
2	$R_C <$ 14.816 km (8 NM)	RNP-4 containment radius	4
3	$R_C <$ 7.408 km (4 NM)	RNP-2 containment radius	4
4	$R_C <$ 3.704 km (2 NM)	RNP-1 containment radius	4
5	$R_C <$ 1852 m (1 NM)	RNP-0.5 containment radius	4
6	$R_C <$ 1111.2 m (0.6 NM)	RNP-0.3 containment radius	4
7	$R_C <$ 370.4 m (0.2 NM)	RNP-0.1 containment radius	4
8	$R_C <$ 185.2 m (0.1 NM)	RNP-0.05 containment radius	4
9	$R_C <$ 75 m and VPL < [112 m]	e.g., WAAS HPL, VPL	2, 3
10	$R_C <$ 25 m and VPL < [37.5 m]	e.g., WAAS HPL, VPL	2, 3
11	$R_C <$ 7.5 m and VPL < [11 m]	e.g., LAAS HPL, VPL	2, 3

<u>Notes for Table 3.1-7</u>:

4. *NIC is reported by an aircraft because there will not be a uniform level of navigation equipage among all users. Although GNSS is intended to be the primary source of navigation data used to report ADS-B horizontal position, it is anticipated that during initial uses of ADS-B or during temporary GNSS outages an alternate source of navigation data may be used by the transmitting A/V for ADS-B position information. The integration of alternate navigation sources is a function that must be performed by the ASA Surveillance Transmit Processing, which then is responsible for determining the corresponding integrity containment radius.*
5. *HPL may be used to represent R_C for GNSS sensors.*
6. *If geometric altitude is not being reported than the VPL tests are not assessed.*
7. *RNP containment integrity refers to total system error containment including sources other than sensor error, whereas horizontal containment for NIC only refers to sensor position error containment.*

3.1.3.9 Navigation Accuracy Category for Position (NAC_p)

The Navigation Accuracy Category for Position (NAC_P) is reported so that surveillance applications may determine whether the reported position has an acceptable level of accuracy for the intended use.

<u>Table 3.1-8</u> defines the navigation accuracy categories that **shall** be used to describe the accuracy of positional information in ADS-B messages from transmitting ADS-B participants.

<u>Table 3.1-8</u>: Navigation Accuracy Categories for Position (NAC_P).

NAC_P	95% Horizontal and Vertical Accuracy Bounds (EPU and VEPU)	Comment	Notes
0	EPU ≥ 18.52 km (10 NM)	Unknown accuracy	3
1	EPU < 18.52 km (10 NM)	RNP-10 accuracy	1,3
2	EPU < 7.408 km (4 NM)	RNP-4 accuracy	1,3
3	EPU < 3.704 km (2 NM)	RNP-2 accuracy	1,3
4	EPU < 1852 m (1NM)	RNP-1 accuracy	1,3
5	EPU < 926 m (0.5 NM)	RNP-0.5 accuracy	1,3
6	EPU < 555.6 m (0.3 NM)	RNP-0.3 accuracy	1,3
7	EPU < 185.2 m (0.1 NM)	RNP-0.1 accuracy	1,3
8	EPU < 92.6 m (0.05 NM)	e.g., GPS (with SA)	1,3
9	EPU < 30 m and VEPU < 45 m	e.g., GPS (SA off)	2,3,4
10	EPU < 10 m <u>and</u> VEPU < 15 m	e.g., WAAS	2,3,4
11	EPU < 3 m <u>and</u> VEPU < 4 m	e.g., LAAS	2,3,4

Notes for Table 3.1-8:

8. *RNP accuracy includes error sources other than sensor error, whereas horizontal error for NAC_P only refers to horizontal position error uncertainty.*
9. *If geometric altitude is not being reported then the VEPU tests are not assessed.*
10. *The Estimated Position Uncertainty (EPU) used is a 95% accuracy bound on horizontal position. EPU is defined as the radius of a circle, centered on the reported position, such that the probability of the actual position being outside the circle is 0.05. When reported by a GPS or GNSS system, EPU is commonly called HFOM (Horizontal Figure of Merit).*
11. *Likewise, Vertical Estimated Position Uncertainty (VEPU) is a 95% accuracy limit on the vertical position. VEPU is defined as a vertical position limit, such that the probability of the actual vertical position differing from the reported vertical position by more than that limit is 0.05. When reported by a GPS or GNSS system, VEPU is commonly called VFOM (Vertical Figure of Merit).*

3.1.3.10 Navigation Accuracy Category for Velocity (NAC_v)

The velocity accuracy category of the least accurate velocity component being supplied by the reporting A/V's source of velocity data **shall** be as indicated in Table 3.1-9.

Table 3.1-9: Navigation Accuracy Categories for Velocity (NAC_V).

NAC_V	Horizontal Velocity Error (95%)	Vertical Geometric Velocity Error (95%)
0	Unknown or ≥ 10 m/s	Unknown or ≥ 50 feet (15.24 m) per second
1	< 10 m/s	< 50 feet (15.24 m) per second
2	< 3 m/s	< 15 feet (4.57 m) per second
3	< 1 m/s	< 5 feet (1.52 m) per second
4	< 0.3 m/s	< 1.5 feet (0.46 m) per second

Notes for Table 3.1-9:

12. *When an inertial navigation system is used as the source of velocity information, error in velocity with respect to the earth (or to the WGS-84 ellipsoid used to represent the earth) is reflected in the NAC_V value.*
13. *When any component of velocity is flagged as not available the value of NAC_V will apply to the other components that are supplied.*
14. *Navigation sources, such as GNSS and inertial navigation systems, provide a direct measure of velocity that can be significantly better than that which could be obtained by position differences.*
15. *NAC_V does not apply to barometric velocity accuracy.*

3.1.3.11 Surveillance Integrity Level (SIL)

The Surveillance Integrity Level (SIL) defines the probability of the integrity containment radius used in the NIC parameter being exceeded, without alerting, including the effects of the airborne equipment condition, which airborne equipment is in use, and which external signals are used by the navigation source. The Surveillance Integrity Limit encoding **shall** be as indicated in Table 3.1-10.

Table 3.1-10: Surveillance Integrity Level (SIL) Encoding.

SIL	Probability of Exceeding the R_C Integrity Containment Radius Without Detection	Comment
0	Unknown	"No Hazard Level" Navigation Source
1	1×10^{-3} per flight hour or per operation	"Minor Hazard Level" Navigation Source
2	1×10^{-5} per flight hour or per operation	"Major Hazard Level" Navigation Source
3	1×10^{-7} per flight hour or per operation	"Severe Major Hazard Level" Navigation Source

Notes for Table 3.1-10:

1. *It is assumed that SIL is a static (unchanging) value that depends on the position sensor being used. Thus, for example, if an ADS-B participant reports a NIC code of 0 because four or fewer satellites are available for a GPS fix, there would be no need to change the SIL code until a different navigation source were selected for the positions being reported in the SV report.*

3.1.3.12 Barometric Altitude Quality (BAQ)

The Barometric Altitude Quality code, BAQ, indicated the accuracy quality of the barometric altitude transmitted and **shall** be encoded as defined in Table 3.1-11.

Table 3.1-11: Encoding for Barometric Altitude Quality (BAQ).

BAQ	Meaning
0	Barometric altitude not certified for IFR use
1	Barometric altitude with 100 feet resolution
2	Barometric altitude with 25 feet resolution
3	Barometric altitude meets RVSM requirements

Note: The above requirements need to be validated by WG4.

3.1.3.13 Barometric Altitude Integrity (NIC_{baro})

The Barometric Altitude Integrity code, $NIC_{baro,}$ **shall** be transmitted to indicate whether or not the barometric pressure altitude transmitted has been crosschecked against another source of pressure altitude.

Note: The above requirements need to be validated by WG4.

3.1.3.14 Air/Ground State

The ADS-B transmitting subsystem **shall** use own aircraft's *air/ground state* to affect which surveillance elements are to be broadcast. The air/ground state **shall** be broadcast in ADS-B messages to other participants.

3.1.3.15 ASA Capability Identification

The ADS-B transmitting subsystem **shall** provide for the transmission of ASA capability identification codes. These codes communicate the following items:

a. TCAS/ACAS installed and operational

b. CDTI display capable

c. Reporting ADS-B Reference Position

d. ASA version number

Note: Future versions of this MASPS may identify additional ASA capability items, therefore provisions should be made to accommodate this future growth.

3.1.3.16 Operational Mode Parameters

The ADS-B transmitting subsystem **shall** provide for the transmission of operational mode parameters. These parameters include the following items:

a. TCAS/ACAS Resolution Advisory active

b. IDENT Switch active

c. Receiving ATC services

d. Emergency/Priority Status

Note: Future versions of this MASPS may identify additional Operational Mode Parameters, therefore provisions should be made to accommodate this future growth.

3.1.3.17 (Reserved) Intent Information

Future versions of this MASPS will provide requirements for intent information elements.

3.2 Data Link System Requirements

Various data links will be used for the transmission and reception of surveillance information supporting ASA applications. This includes both the systems used (e.g. ADS-B and TIS-B) and the media on which the data is transmitted (e.g. 1090 MHz Extended Squitter, UAT, or VDL-4). It is necessary to make sure that any system or medium used to convey ASA data does so at a level sufficient to support ASA applications and allow ASA systems to function as specified elsewhere in these MASPS. The requirements specified in this section are meant to set high level functional and performance standards for surveillance data links supporting ASA. More detailed system standards can be found in the ADS-B MASPS (DO-242A) and TIS-B MASPS (DO-

XXX). Specific system performance requirements can be found in the data link MOPS for 1090 MHz (DO-260A) and UAT (DO-182) as well as the VDL-4 SARPS (??????)

3.2.1 Data Link Media Functional Requirements

<<Editor's Note: When reading the below text, the highlighted notes "J&T#??" are used to indicate the inclusion of the suggested requirements from Joel and Tom in the file "draft_AI#01-29-03-03_Message_Int_Req_2003-02-13.doc".>>

Operational Environment

<<J&T#3>>The ASA Surveillance Data Link (i.e. ADS-B, TIS-B) RF medium **shall** be suitable for all-weather operation. <<J&T#6>>Radio frequencies used for ASA Surveillance message transmission **shall** operate in an internationally allocated aeronautical radionavigation band(s). Data Link system performance will be specified relative to a defined interference environment for the medium.

Minimum Functionality

ASA is dependant on the appropriate surveillance data being available under expected operating conditions. <<J&T#1>>The ASA Surveillance Data Link medium **shall** be able to support air-to-air and air-to-ground transfer of data for ADS-B systems and ground-to-air transfer of data for TIS-B systems. All ASA Surveillance Data Link systems **shall** transmit and receive all data necessary for the ASA applications supported by the system's ASA Level.

<<J&T#9>>It is important that messages from different data link systems such as ADS-B and TIS-B be distinguishable from each other. Messages **shall** be encoded such that the transmitting system of the message (i.e. ADS-B, TIS-B) can be identified.

3.2.2 Data Link System Performance Requirements

3.2.2.1 Data Exchange Requirements

Any data link system used to support ASA must be able to perform at levels and ranges as required by the supported ASA applications. Minimum performance requirements for each ASA Level are specified in Table 2-4 (§2.XX). All data link systems supporting a particular ASA Level must meet those performance requirements.

Acquisition and Update Rate

<<J&T#5>>For each ASA Level, the data link **shall** acquire all mode status and state vector data for 95% of the observable user population at the **farthest** operational range specified by the Coverage requirement (#15) in Table 2-4 (§2.XX). Report acquisition is defined as the reception of all report elements from a transmitting ASA participant required by the supported applications of the receiving ASA participant. <<Do we need to place requirements for on-condition messages here as well? We could say " . . . **shall** acquire all mode status, state vector, and application specific data for 95% . . .>>

Data pertaining to the operational status of a given aircraft (i.e. 24 bit address, aircraft capabilities, quality of broadcast data) and contained in Mode Status reports of ADS-B systems, is relatively static. Therefore, if the acquisition range requirement is met for this data, it can be assumed that the update rate for that data within the acquisition range will be sufficient. However, position and velocity data, contained in State Vector reports of ADS-B systems, is constantly changing. This is a major aspect of specifying ASA applications and requires that update rate requirements be placed on this data. <<J&T#4>>For each ASA Level, the data link **shall** meet the most stringent requirements shown in Table 2-4 (§2.XX) for Effective Update Rate (requirement #9) within the operational range specified by the Coverage requirement (#15) with 95% probability for 95% of the observable user population for all state vector <<??and application specific??>> data.

Data Accuracy and Latency

The operational range and safety criticality of an application are the two most significant factors in accuracy and latency requirements for that application. For each ASA Level, the data link **shall** meet the most stringent requirements specified for position, heading and velocity accuracy (#1-5) in Table 2-4 (§2.XX). For each ASA Level, the data link **shall** meet the most stringent requirements specified for Latency (#12) in Table 2-4 (§2.XX).

<<Editor's note: Do we want to refer all requirements back to Table 2-4, or repeat those requirements in summary tables here such as Table 3.2-1 & Table 3.2-2 found below??>>

Table 3.2-1: ADS-B Latency Requirements (in Seconds)

	ASA ASA Level				
Data Category	Basic	Intermediate	Advanced 1	Advanced 2	Notes
Target Identification	2	?			
Target State Vector Data	2	?			
Special	2				

Table 3.2-2: ADS-B Accuracy Requirements

	ASA ASA Level				
Data Category	Basic	Intermediate	Advanced 1	Advanced 2	Notes
Target Identification					
Target State Vector Data					
Special					

3.2.2.2 Data Link Network Capacity

Any data link system supporting air-to-air surveillance and ASA applications must be designed to accommodate expected future peak airborne traffic levels, as well as any airport surface units within range. The three traffic scenarios described below are taken from the summary published by the Technical Link Assessment Team (TLAT) in Appendix H of the Technical Link Assessment Report, March 2001 [ref. 4]. The March 2001 TLAT Report summarizes the technical assessment of ADS-B/situational awareness links commissioned by both the Safe Flight 21 (SF21) Steering Committee consistent with the recommendations of the RTCA Free Flight Select Committee and the Eurocontrol ADS Programme Steering Group (PSG). The March 2001 TLAT Report builds upon the November 1999, Phase One Report developed by a precursor to the TLAT, the SF21 Technical ADS-B Link Evaluation Team. Two of these scenarios represent expected future peak interference environments in the United States and Europe. These were developed to analyze link capacity for operational ranges of 40 nmi and less. The third scenario is a low density model used to analyze link capacity for ranges beyond 40 nmi. *<<Are these last two sentences correct? Are they helpful?>>* Figure 3.2.2.2-1 depicts the total traffic for each scenario as a function of range as the are numerically specified in Table 3.2.2.2-1.

Note 1: The numbers given in Table 3.2.2.2-1 are meant to be approximations of the number of aircraft and should not be interpreted as definitive quantities for these traffic scenarios.

<<J&T#2>>Equipment supporting the Basic and Intermediate ASA Levels **shall** meet all performance requirements specified in Table 2-4 (§2.XX) (requirements 8 through 15) for the high density traffic scenarios Core Europe 2015 (§3.2.2.1.1) and LA 2020 (§3.2.2.1.2), as defined below. Equipment supporting Advanced ASA Applications with an operational range of 40 nmi or less as specified by the Coverage requirement (#15) in Table 2-4 (§2.XX) **shall** also meet all performance requirements specified in Table 2-4 (§2.XX) (requirements 8 through 15) for the high density traffic scenarios Core Europe 2015 (§3.2.2.1.1) and LA 2020 (§3.2.2.1.2), as defined below. Equipment supporting Advanced ASA Category Applications with an operational range beyond 40 nmi as specified by the Coverage requirement (#15) in Table 2-4 (§2.XX) **shall** meet all performance requirements for those applications specified in Table 2-4 (requirements 8 through 15) for the low density traffic scenario (§3.2.2.1.3) defined below.

Note 2: As operational concepts mature and applications are validated future versions of these MASPS may require Advanced ASA Applications with operational ranges beyond 40 nmi to meet performance requirements in the high density traffic scenarios at those extended ranges.

Table 3.2.2.2-1: Number of airborne aircraft and range distributions.

	RANGE (nmi)							
	50	100	150	200	250	300	350	400
LA 99	175	350	525	700	883	1103	1362	1661
LA 2020	257	532	797	1071	1312	1655	2054	2469
Europe 2005	124	306	622	826				
Europe 2015	188	404	836	1348	1613	1942		
Low density	6	23	51	90	141	203	276	360

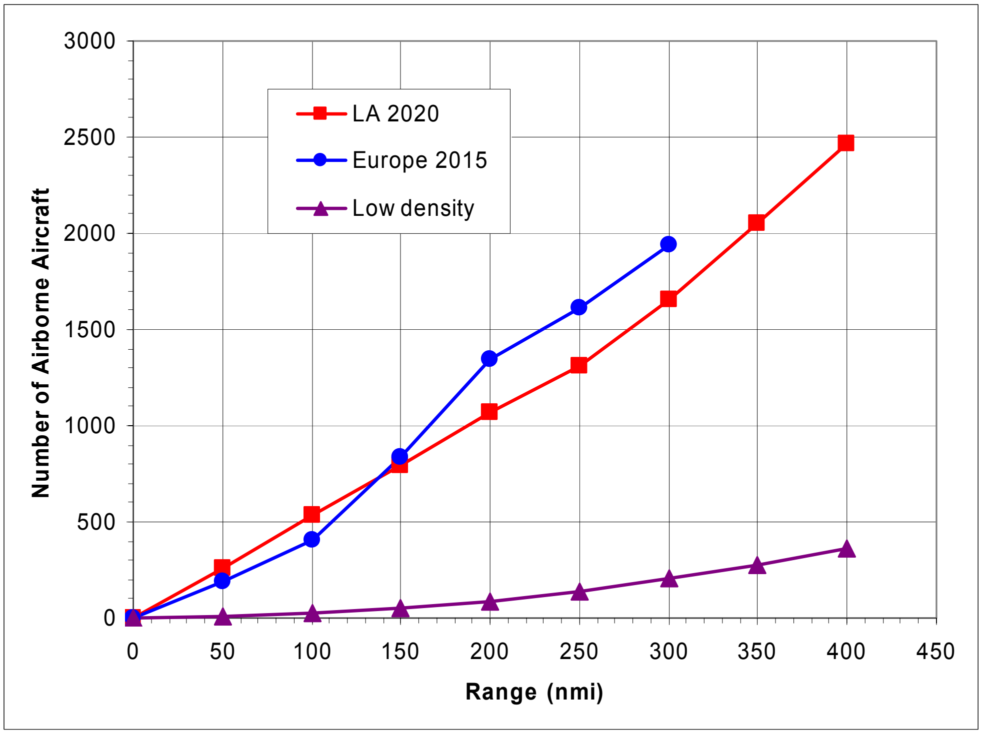


Figure 3.2.2.2-1: Cumulative Range Distributions of Traffic Scenarios

The two geographical areas which underlie the two high density scenarios discussed below (LA Basin and Core Europe) correspond to very different types of situations for an aircraft to operate in, and thus should provide two diverse environments for evaluation. The LA Basin scenario contains only about 14% of all airborne aircraft at altitudes above 10000 ft, while the Core Europe scenario has around 60% above 10000 ft. Thus, there will be vastly different numbers of aircraft in view for the two scenarios. Additionally, the aircraft density distributions are also quite different, which will place different stresses on the data link systems.

3.2.2.2.1 Core Europe 2015 Scenario

For the Core Europe 2015 scenario, the distributions and assumptions made were taken directly from the Eurocontrol document entitled "High-Density 2015 European Traffic Distributions for Simulation," dated August 17, 1999. [Add reference] This scenario is fairly well-defined and straightforward to apply.

This scenario includes a total of 2091 aircraft (both airborne and ground), and is based on the following assumptions:

- There are five major TMAs (Brussels, Amsterdam, London, Paris, and Frankfurt), each of which is characterized by:

    a. The inner region (12 nm radius) contains 29 aircraft at lower altitudes,
    b. The outer region (50 nm radius) contains 103 aircraft at mid to higher altitudes.
    c. There are assumed to be 25 aircraft on the ground, within a 5 nm radius, plus another 25 aircraft randomly distributed throughout the entire scenario area.

- These aircraft are assumed to be symmetrically distributed rotationally, and the aircraft in an altitude band are assumed to be uniformly distributed throughout the band. However, all aircraft in the same band are assumed to be traveling at the same band-dependent velocity.

- Superimposed over these aircraft is a set of airborne en route aircraft, which are distributed over a circle of radius 300 nm. These aircraft are distributed over four altitude bands, ranging from low to upper altitudes. They also travel at velocities which are altitude band dependent.

- All aircraft are assumed to be ADS-B equipped. All aircraft above 10000 feet are assumed to be either ADS-B MASPS equipage class A3 (75%) or A2 (25%), while below 10000 feet, the ratios are adjusted to give the entire ensemble of aircraft the following proportions of equipage:

    a. 30 % A3
    b. 30% A2
    c. 30% A1
    d. 10% A0

  Note: *Aircraft equipage is assigned according to altitude. The lower percentages of A0 and A1 aircraft than those found in the LA Basin scenarios reflect differences in operating conditions and rules in European airspace.*

3.2.2.2.2 LA 2020 Scenario

This scenario was based on the LA Basin 1999 maximum estimate. It was assumed that air traffic in this area would increase by a few percent each year until 2020, when it would be 50 % higher than in 1999.

The following assumptions went into generating the airborne and ground aircraft for the LA Basin 2020 scenario:

- The density of airborne aircraft was taken to be:

    a. Constant in range from the center of the area out to 225 nautical miles (5.25 aircraft/nm), (i.e., the inner circle of radius one nm would contain approximately five aircraft, as would the ring from 224 to 225 nm) and
    b. Constant in area from 225 nm to 400 nm (.00375 aircraft/nm^2).

- There were assumed to be a fixed number of aircraft on the ground (within a circle of radius 5 nm at each airport), divided among LAX, San Diego, Long Beach, and five other small airports. Half of the aircraft at each airport were assumed to be moving at 15 knots, while the other half were stationary. The approximate cumulative distribution of these aircraft on the ground from the center point of the area is as follows:

  a. 143 within 50 nmi
  b. 190 within 100 nmi
  c. 225 beyond 150 nmi

- The altitude distribution of the airborne aircraft was assumed to be exponential, with a mean altitude of 5500 feet. This distribution was assumed to apply over the entire area.

  Note: *The TLAT LA2020 traffic scenario did not account for local terrain as it assumed a smooth earth model. For improved fidelity, adjustment off the aircraft altitudes in the traffic scenarios appropriate when used in conjunction with a link performance model that includes terrain.*

- The airborne aircraft were assumed to have the following average velocities, determined by their altitude. The aircraft velocities for aircraft below 25000 feet will be uniformly distributed over a band of average velocity +/- 30 percent.

  a. 0-3000 feet altitude 130 knots
  b. 3000-10000 ft 200 knots
  c. 10000-25000 ft 300 knots
  d. 25000-up 450 knots

- The aircraft are all assumed to be moving in random directions.

- As with Core Europe 2015, all aircraft above 10000 feet are assumed to be either ADS-B MASPS equipage class A3 (75%) or A2 (25%), however, for LA2020, the ratios are adjusted to give the entire ensemble of aircraft the following proportions of equipage below 10000 feet:

  a. A3 30%
  b. A2 10%
  c. A1 40%
  d. A0 20%

The scenario for the 2020 high density LA Basin case contained a total of 2694 aircraft: 1180 within the core area of 225 nm, 1289 between 225-400 nm, and 225 on the ground. This represents a scaling of the estimated maximum 1999 LA Basin levels upward by 50 percent. Of these aircraft, 471 lie within 60 nm of the center. (This includes aircraft on the ground.) Around ten percent of the total number of aircraft are above 10000 ft in altitude, and more than half of the aircraft are located in the outer (non-core) area of the scenario.

An attempt was made to at least partially account for the expected lower aircraft density over the ocean. In the third quadrant (between 180 degrees and 270 degrees), for distances greater than 100 nm from the center of the scenario, the density of aircraft was reduced to 25 % of the nominal value used. The other 75 % of aircraft which would have been placed in this area were distributed uniformly among the other three quadrants at the same range from the center. This results in relative densities of 1:5 between the third quadrant and the others.

3.2.2.2.3 Low Density Scenario

For simplicity, the number of aircraft for the third scenario was set by scaling the current maximum LA Basin levels downward by a factor of five, amounting to 360 total aircraft. These aircraft are uniformly distributed in the horizontal plane within a circle of 400 nautical miles. In the vertical direction, they are distributed uniformly between 25,000 feet and 37,000 feet. The velocities are all set to 450 knots and are randomly distributed in azimuth. All of the aircraft are assumed to be A3 equipped.

3.2.3 System Specific Requirements

3.2.3.1 ADS-B (Do we need ADS-B specific section?)

Add ADS-B data link requirements here.

3.2.3.2 TIS-B (Do we need TIS-B specific section?)

Add ADS-B data link requirements here.

3.3 ASA Receiving Participant Subsystems

ASA receive subsystems include the ADS-B/TIS-B Receiver, (treated in §3.3.1), Airborne Surveillance and Separation Assurance Processing (ASSAP, treated in §3.3.2), and the Cockpit Display of Traffic Information (CDTI, treated in §3.3.3). Each of these three subsections is further broken into functional, performance, and interface requirements, e.g., §3.3.1.1 describes functional requirements for the ADS-B receiver, §3.3.1.2 specifies performance requirements for the receiver, and §3.3.1.3 specifies interface requirements for the ADS-B receiver. Note that to avoid repetition, all interface requirements are specified as interfaces *to* a particular subsystem.

3.3.1 ADS-B/TIS-B Receiver Requirements

3.3.1.1 ADS-B/TIS-B Receiver Subsystem Functional Requirements

The ADS-B/TIS-B receiver is expected to receive the appropriate link specific signal in space, detect and/or correct bit errors as appropriate, and conduct appropriate link specific monitoring functions.

The ADS-B / TIS-B receiver **shall** receive link dependent messages from all ADS-B / TIS-B transmit subsystems within range as per §3.2, and **shall** assemble ADS-B and TIS-B reports, including the state vector report (Table 3-1) and the Mode Status Report (Table 3-2). The appropriate ADS-B report **shall** be updated and made available to ASSAP each time any new (changed) information is received for an A/V across the ADS-B / TIS-B link.

Table 3-1: Surveillance State Vector Report

	SV Elem. #	Contents	Required from airborne participants	Required from surface participants	Reference Section
ID	1	Participant Address	•	•	
	2	Address Qualifier	•	•	
TOA	3	Time Of Applicability	•	•	
Geometric Position	4a	Latitude (WGS-84)	•	•	
	4b	Longitude (WGS-84)	•	•	
	4c	Horizontal Position Valid	•	•	
	5a	Geometric Altitude	•		
	5b	Geometric Altitude Valid	•		
Horizontal Velocity	6a	North Velocity while airborne	•		
	6b	East Velocity while airborne	•		
	6c	Airborne Horizontal Velocity Valid	•		
	7a	Ground Speed while on the surface		•	
	7b	Surface Ground Speed Valid		•	
Heading	8a	Heading while on the Surface		•	
	8b	Heading Valid		•	
Baro Altitude	9a	Pressure Altitude	•		
	9b	Pressure Altitude Valid	•		
Vertical Rate	10a	Vertical Rate (Baro/Geo)	•		
	10b	Vertical Rate Valid	•		
NIC	11	Navigation Integrity Category	•	•	

Table 3-8: Mode-Status (MS) Report Definition.

	MS Elem. #	Contents	Reference Section
ID	1	Participant Address	
	2	Address Qualifier	
TOA	3	Time of Applicability	
Version	4	ADS-B Version Number	
ID, Continued	5a	Call sign	
	5b	Emitter Category	
	5c	A/V Length and Width Codes	
Status	6a	Mode-Status Data Available	
	6b	Emergency/Priority Status	
CC, Capability Codes	7	Capability Class Codes	
		7a: TCAS/ACAS installed and operational	
		7b: CDTI display capability	
		7c: (Reserved for Service Level)	
		7d: ARV report Capability Flag	
		7e: TS report Capability Flag	
		7f: TC report Capability Level	
		7g: Reporting ADS-B Reference Position	
		(CC Codes reserved for future growth)	
OM, Operational Mode	8	Operational Mode Parameters	
		8a: TCAS/ACAS resolution advisory active 8b: IDENT Switch Active 8c: Receiving ATC services (Reserved for future growth)	
SV Quality	9a	Nav. Acc. Category for Position (NAC_P)	
	9b	Nav Acc. Category for Velocity (NAC_V)	
	9c	Surveillance Integrity Level (SIL)	
	9d	Barometric Altitude Quality (BAQ)	
	9e	NIC_{baro} - Altitude Cross Checking Flag	
Data Reference	10a	True/Magnetic Heading	
	10b	Vertical Rate Type (Baro./Geo.)	
Other	11	Reserved for Flight Mode Specific Data	

3.3.1.1.1 Future: Additional requirements for Advanced ASA Systems

Advanced ASA systems **will** require additional data for the approach spacing application. In particular, transmission of plan data consisting of a vector of planned speed reduction ranges and planned speeds are necessary.

Note: These reports will be defined in a later revision of this MASPS.

3.3.1.1.2 Future: Reserved

Requirements for the reserved ASA level are to be defined. However, it is expected that this ASA level will support Airborne Conflict Mangement using intent based information.

3.3.1.2 ADS-B/TIS-B Receiver Subsystem Performance Requirements

Data latencies and accuracies are specified in §3.2 for the ADS-B system as a whole (including the ADS-B transmitter and the receiver).

The availability risk, continuity risk, and integrity risk requirements of Table 3-2 **shall** be met by the ADS-B/TIS-B receiver subsystem. Note that for both basic and intermediate ASA levels, there are no requirements.

Definitions of subsystem integrity, availability, and continuity are provided below.

Table 3-2: ADS-B / TIS-B Receiver Availability, Continuity, and Integrity Requirements (Failure rate per flight hour or operation)

NOTE: THIS TABLE IS WORK IN PROGRESS AND IS SUBJECT TO CHANGE

	ASA Level			
Feature	**Basic**	**Intermediate**	**Advanced**	**Reserved**
Subsystem Availability Risk	10^{-3}	10^{-3}	10^{-4}	TBD
Subsystem Continuity Risk	10^{-3}	10^{-4}	10^{-4}	TBD
Subsystem Integrity Risk	10^{-3}	10^{-3}	10^{-5}	TBD

Note N/R = No Requirement

Subsystem Integrity Risk

Subsystem Integrity Risk is the probability, per flight hour, that a given subsystem will have an undetected failure and consequently, that the subsystem will provide misleading information.

Subsystem Continuity Risk

Subsystem continuity risk is the probability per hour, that, given that the subsystem was operating at the start of the hour or operation, that the subsystem will fail to be available through the remainder of the hour or operation.

Subsystem Availability Risk

Subsystem availability risk is the probability per flight hour or operation that the subsystem is not available, i.e., the subsystem is not meeting its functional and performance requirements.

3.3.1.3 Interface Requirements *to* the ADS-B/TIS-B Receiver Subsystem

There are no interfaces to the ADS-B/TIS-B receiver from within ASA that are specified within this MASPS. ADS-B messages interface between the transmitting ship's ADS-B transmitter and the receiving ship's ADS-B/TIS-B receiver. These messages are data link dependent and are specified in link dependent ADS-B MOPS.

3.3.2 Airborne Surveillance and Separation Assurance Processing (ASSAP) Subsystem Requirements

ASSAP is the surveillance and separation assurance processing component of ASA. ASSAP processes incoming data from other aircraft/vehicles and derives information for display on the CDTI, as well as alerting and guidance information that will also be displayed. Flight crew command and control inputs that affect application functions are also processed by ASSAP. ASSAP consists of three sub-functions, as illustrated in Figure 3.1-2:

1. A surveillance processing sub-function that integrates surveillance data from multiple sources, establishes tracks, and determines the surveillance quality of targets.
2. A function to process coupled applications – deriving specific alert and guidance information to provide to the flight crews
3. A function to process background applications, deriving required alerts and guidance for conflict detection and airborne conflict management.

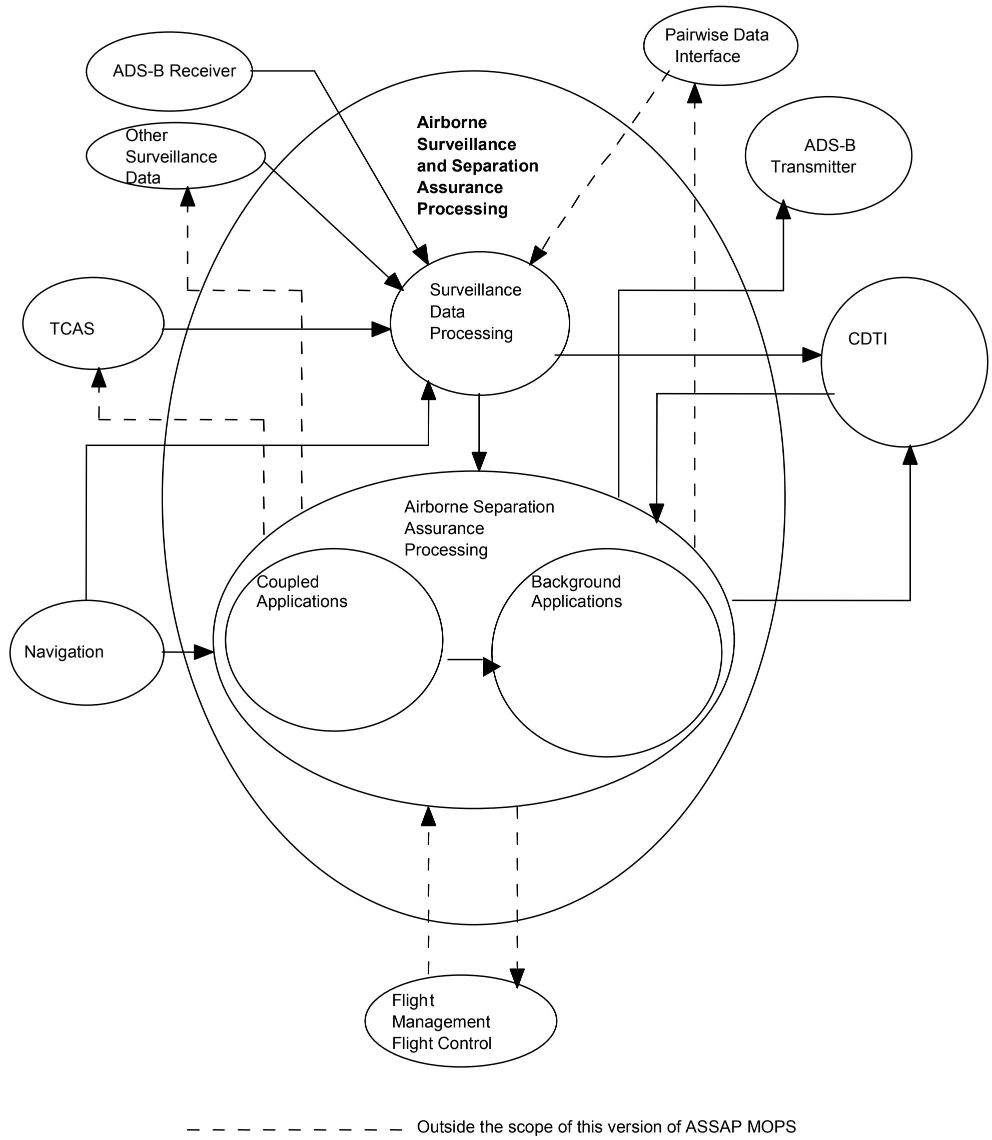


Figure 3.3-1: ASSAP Components

Ed Note: figure still needs revision to make it consistent with other figures

3.3.2.1 ASSAP Functional Requirements

ASSAP functional requirements are broken into surveillance processing requirements (§3.3.2.1.1) and applications processing requirements (§3.3.2.1.2).

3.3.2.1.1 ASSAP Surveillance Processing Requirements

The ASSAP surveillance processing as described below is required for all ASA levels.

ASSAP surveillance processing function receives information for target A/V's from various surveillance sources, correlates the data, registers the data, and outputs a track file consisting of state and other information about each A/V under track. Requirements for the surveillance sub-function follow.

1. ASSAP **shall** provide a tracking function. The tracking function **shall** include:

   a. A correlation function that associates target data from different surveillance sources that relate to the same aircraft/vehicle track, i.e.,

      The correlation function **shall** associate and cross-reference target data from ADS-B targets, TIS-B targets, and TCAS targets. The correlation function **shall** continually monitor and update the target cross references.

   b. A registration bias estimation function that estimates systematic biases between sensors.

   c. A registration correction function that registers measurements (including time, position, and velocity) from different surveillance sources,.

   d. An estimation function that estimates track state based on one or more surveillance source inputs. Track state includes time, horizontal position, horizontal velocity, altitude, altitude rate, heading (if possible), and track quality, including accuracy, integrity containment boundary, and integrity containment risk (see §2.4.5).

      The estimation function may combine information from different data sources into a single track. ASSAP surveillance processing **shall** not degrade the quality (accuracy or integrity containment boundary or integrity containment risk) of the data it receives from any single surveillance source, but may enhance the quality (accuracy and/or integrity) of the track information, using techniques such as Kalman filters. ASSAP **shall** estimate the quality of the track state information that is maintained in the track file.

      Tracks **shall** be initiated, extrapolated, and terminated over appropriate intervals, see Table 2-4.

Ed. Note: more detail to be provided on track initiation, coasting intervals, and track drop criteria

2. Correlation of TCAS data: If TCAS data is to be integrated on the CDTI, ASSAP **shall** correlate the TCAS tracks with its internal tracks to the extent practicable. For correlated TCAS tracks ASSAP **shall** recognize if a track has an active TCAS resolution advisory or traffic advisory, and **shall** provide that information in the track file (see Table 3-3).

3. TIS-B / ADS-B correlation: while it is normally expected that TIS-B and ADS-B information (on a given link) will be mutually exclusive, the possibility exists that an ASA participant will receive TIS-B and ADS-B information on the same aircraft. Therefore, ASSAP surveillance processing **shall** cross-correlate the targets from TIS-B and ADS-B reports supplied by the ADS-B receiver. The correlation should make use of all available data that can assist in this process from the state vector and other reports.

4. ASSAP surveillance processing **shall** maintain, for each A/V under track, a file that contains, at a minimum, the elements listed in Table 3-3. Fields should be filled in to the extent possible based on received surveillance data. For definitions of the data items contained in Table 3-3.

5. ASSAP surveillance processing **shall** determine target qualification for ASA level based on service level as per Table 2-4.

6. ASSAP **shall** extrapolate target state position information to the current time at the interface with the CDTI with at least a 1 Hz rate.

Table 3-3: Surveillance Elements of the ASSAP track file

NOTE: THIS TABLE IS WORK IN PROGRESS AND IS SUBJECT TO CHANGE

	Track File Element #	Contents	Reference Section
ID	1	Participant Address	
	2	Address Qualifier	
		Call Sign	
TOA	3	Time Of Track State Vector	
		Time of last measurement update	
Geometric Position	4a	Latitude (WGS-84)	
	4b	Longitude (WGS-84)	
	4c	Horizontal Position Valid	
	5a	Geometric Altitude	
	5b	Geometric Altitude Valid	
Horizontal Velocity	6a	North Velocity	
	6b	East Velocity	
	6c	Airborne Horizontal Velocity Valid	
	7a	Ground Speed while on the surface	
	7b	Surface Ground Speed Valid	
Heading	8a	Heading while on the Surface	
	8b	Heading Valid	
Baro Altitude	9a	Pressure Altitude	
	9b	Pressure Altitude Valid	
Vertical Rate	10a	Vertical Rate (Baro/Geo)	
	10b	Vertical Rate Valid	
		Emitter Category	
		A/V Length and Width Codes	
		Emergency / Priority Status	
		ASA Level	
		Navigation Integrity Category (NIC)	
		Nav. Acc. Category for Position (NAC_P)	
		Nav Acc. Category for Velocity (NAC_V)	
		Surveillance Integrity Level (SIL)	
		Barometric Altitude Quality (BAQ)	
		NIC_{baro} - Altitude Cross Checking Flag	
		True/Magnetic Heading	
		Vertical Rate Type (Baro./Geo.)	
		Reserved for Flight Mode Specific Data	
		Correlated TCAS Track ID	
		TCAS RA Active	
		TCAS TA Active	

3.3.2.1.1.1 Definitions

This section contains definitions of terms used above.

Track: A sequence of measurements and state information relating to a particular aircraft or vehicle.

Track State: The basic kinematic variables that define the state of the aircraft or vehicle of a track, e.g., position, velocity, acceleration.

Covariance: A two dimensional symmetric matrix representing the uncertainty in a track's state. The diagonal entries represent the variance of each state; the off-diagonal terms represent the covariances of the track state.

Registration: The process of aligning measurements from different sensors by removing systematic biases.

Correlation: The process of determining that a new measurement belongs to an existing track.

Estimation: The process of determining a track's state based on new measurement information

Extrapolation: The process of moving a track's state forward in time based on the track's last estimated kinematic state.

3.3.2.1.2 ASSAP Applications Processing Requirements

ASSAP **shall** make *ASSAP track reports* available to the CDTI for all active applications.

Note: *Precise conditions under which airborne and surface targets are to be displayed and filtered is to be developed in the ASSAP/CDTI MOPS. See section 3.3.3 for filtering requirements on the CDTI.*

ASSAP track reports elements are listed in Table 3-4.

Table 3-4: ASSAP Track Report Elements

NOTE: THIS TABLE IS WORK IN PROGRESS AND IS SUBJECT TO CHANGE

	Track File Element #	Contents	Reference Section
ID	1	Participant Address	
	2	Address Qualifier	
		Call Sign	
TOA	3	Time Of Track State Vector	
		Time of last measurement update	
Geometric Position	4a	Latitude (WGS-84)	
	4b	Longitude (WGS-84)	
	4c	Horizontal Position Valid	
	5a	Geometric Altitude	
	5b	Geometric Altitude Valid	
Horizontal Velocity	6a	North Velocity	
	6b	East Velocity	
	6c	Airborne Horizontal Velocity Valid	
	7a	Ground Speed while on the surface	
	7b	Surface Ground Speed Valid	
Heading	8a	Heading while on the Surface	
	8b	Heading Valid	
Baro Altitude	9a	Pressure Altitude	
	9b	Pressure Altitude Valid	
Vertical Rate	10a	Vertical Rate (Baro/Geo)	
	10b	Vertical Rate Valid	
		Emitter Category	
		A/V Length and Width Codes	
		Emergency / Priority Status	
		ASA Level	
		Navigation Integrity Category (NIC)	
		Nav. Acc. Category for Position (NAC_P)	
		Nav Acc. Category for Velocity (NAC_V)	
		Surveillance Integrity Level (SIL)	
		Barometric Altitude Quality (BAQ)	
		NIC_{baro} - Altitude Cross Checking Flag	
		Degraded / insufficient quality – ASSA	
		Degraded / insufficient quality – EV Acq	
		True/Magnetic Heading	
		Vertical Rate Type (Baro./Geo.)	
		Reserved for Flight Mode Specific Data	
		Correlated TCAS Track ID	
		TCAS RA Active	
		TCAS TA Active	

3.3.2.1.2.1 Basic ASA

ASSAP track quality (§3.3.2.1.1) **shall** be compared with acceptable values for basic applications, see Table 2-4. The track data base **shall** be updated to reflect any degraded condition for EV acquisition or ASSA, as appropriate, see table 3-4. The track data base **shall** indicate if the track's quality is insufficient for a basic application.

If the installed system has the option for conflict detection (CD), ASSAP **shall** determine if each track is eligible for CD processing, as per Table 2-4. Each track that is eligible for CD **shall** be processed by the CD alerting function, and CAZ alerts or CDZ alerts **shall** be issued as appropriate. ASSAP **shall** include in the ASSAP track report the status of the CAZ alert and the CDZ alert.

Normative Appendix D for conflict detection defines scenarios, and boundaries for CAZ and CDZ over which CD alerts are to be tested, and criteria for false alarms and missed detections. In accordance with appendix D, the ASSAP MOPS **shall** define an algorithm for Conflict Detection that meets the minimum requirements of Table 3-4:

Table 3-4: Missed Detection and False Alarm Requirements for Conflict Detection

Scenario Set (See note)	False Alarm Rate CAZ	False Alarm Rate CDZ	Missed Detection Rate CAZ	Missed Detection Rate CDZ
GA Pattern				
ARTS data layer 1				
ARTS data layer 2				
ARTS data layer 3				
ARTS data layer 4				
ARTS data layer 5				

Note: Scenario sets are based on agreed scenarios for GA pattern approaches and recorded (ARTS) data at differing altitudes "layers," and are described in detail in Appendix D.

3.3.2.1.2.2 Intermediate ASA

There are no specific additional application processing requirements for intermediate ASA.

3.3.2.1.2.3 Advanced ASA

ASSAP **will** process ASIA, ACM, and CSPA applications based on future algorithms to be determined.

3.3.2.2 ASSAP Performance Requirements

General requirements for ASSAP are as follows:

1. ASSAP **shall** introduce a data latency of no more than 200 mS between the time data is received from the surveillance source (ADS-B/TIS-B receiver, TCAS) at the ASSAP interface and the time that the data is presented to the CDTI interface.

(Ed Note: may split requirement between surveillance data outputs and outputs derived from applications processing, e.g., alerts vs. position, may be a delay in issuing the alert vs displaying the position.)

2. ASSAP shall achieve the subsystem integrity risk, continuity risk, and availability risk requirements listed in Table 3-4.

Table 3-4: ASSAP Availability, Continuity, and Integrity Requirements (Failure rate per flight hour or operation)

NOTE: THIS TABLE IS WORK IN PROGRESS AND IS SUBJECT TO CHANGE

	ASA Level			
Feature	**Basic**	**Intermediate**	**Advanced**	**Reserved**
Subsystem Availability Risk	10^{-3}	10^{-3}	10^{-4}	TBD
Subsystem Continuity Risk	10^{-3}	10^{-4}	10^{-4}	TBD
Subsystem Integrity Risk	10^{-3}	Tbd	10^{-5}	TBD

Note N/R = No Requirement

3.3.2.3 ASSAP Interface Requirements

ASSAP provides the central processing for ASA, and interfaces with many other avionics subsystems. Table 3.3-8 indicates the required data interfaces to ASSP. All data indicated by a dot (•) **shall** be provided to the ASSAP function, with the exception of those items labeled "future." All data in Table 3.3-8 indicated by the letter "d" are optional, desired, interfaces.

Each data item listed in the table is described in detail below.

Note: Some of these data item names are re-used in subsequent requirements tables; the definitions will not be repeated for items with identical names and definitions.

Table 3.3-8: Interfaces to ASSAP

Source	Info Category	Information Element	ASA Level			
			Basic		Intermediate	Advanced
			Airborne	ASSA & FAROA		
ADS-B / TIS-B Receiver	Target ID	Call Sign	d	d	•	•
		Address	•	•	•	•
		Category	d	d	d	•
		A/V length and width codes		•		
	Target State Data	Time of applicability (TOA)	•	•	•	•
		Horizontal Position	•	•	•	•
		Horizontal Velocity	•	•	•	•
		Altitude	•	•	•	•
		Altitude Rate	•	•	•	•
		Heading		•		
	Target Quality	NIC	•	•	•	•
		SIL	•	•	•	•
		NAC_P	•	•	•	•
		NAC_v	•	•	•	•
	Special	Future: Planned Final Approach Speed				•
TCAS	TCAS related data (note 1)	RA Active	•		•	•
		TA Active	•		•	•
		Range	•		•	•
		Bearing	•		•	•
		Altitude (Mode C Code) (note 2)	•		•	•
		TCAS altitude rate (note 3)	•		•	•
		Mode S Address (note 2)	•		•	•
		TCAS Track ID (2)	•		•	•

Source	Info Category	Information Element	ASA Level: Basic: Airborne	ASA Level: Basic: ASSA & FAROA	ASA Level: Intermediate	ASA Level: Advanced
Navigation	Own ship state data	TOA	•	•	•	•
		Horizontal Position	•	•	•	•
		Horizontal Velocity	•	•	•	•
		Altitude	•	•	•	•
		Vertical Rate	•	•	•	•
		Heading	•	•	•	•
	Ownship quality	Integrity containment radius	•	•	•	•
		Integrity containment probability	•	•	•	•
		Horizontal Position Accuracy	•	•	•	•
		Horizontal Velocity Accuracy	•	•	•	•
CDTI	Flight Crew Inputs	Selected coupled application			•	•
		Selected target			•	•
		Alert zone selection			•	•
		Future: Own ship Planned final approach speed				•
?	Ownship ID	Future: Category				•

• = Required; d = desired

<u>*Notes:*</u>

1. *Required if TCAS is present in the configuration and an integrated TCAS/ASA traffic display is used.*
2. *This information requires a change to the standard TCAS bus outputs defined in ARINC 735A which currently does not provide the Mode S and Mode A address codes, nor does it necessarily output Mode C.*
3. *For display of up/down arrow if there is no ADS-B track that correlates with the TCAS track.*

3.3.2.3.1 Interfaces to ASSAP from the ADS-B/TIS-B Receiver

3.3.2.3.1.1 Target Identification

The basic identification information to be conveyed to ASSAP includes the following elements: call sign, address, category, and A/V length and width codes. The definitions for these data items are as per §3.3.1

3.3.2.3.1.1.1 Time of Applicability (TOA)

Time of Applicability (TOA) is associated with each state report for the target or for own-ship. TOA indicates the time at which the reported state values were valid. TOA shall be reported to ASSAP for target state data and for own-ship state data.

3.3.2.3.1.1.2 Horizontal Position

Horizontal position reported to ASSAP shall consist of latitude and longitude referenced to the WGS-84 ellipsoid. The definition of horizontal position is as per §3.3.1 Horizontal Velocity

Horizontal velocity shall be reported to ASSAP in north-south and east-west coordinates relative to the WGS-84 coordinate system as per definitions in §3.3.1.

3.3.2.3.1.1.3 Altitude

Both target barometric pressure altitude and geometric shall be provided, if available, to ASSAP. If the target is on the airport surface no altitude is required but an indication shall be provided to ASSAP. Barometric and geometric altitudes are as defined in §3.3.1.

3.3.2.3.1.1.4 Vertical Rate

Target altitude rate is as defined in §3.3.1.

Heading

Heading is as defined in §3.3.1. An indication shall be provided to ASSAP as to whether the heading is measured from true north or magnetic north. Note that heading is required for surface applications only.

3.3.2.3.1.2 Target Quality

Target quality as communicated from surveillance systems shall consist of Navigation integrity category for position (NIC), Surveillance Integrity Level (SIL), navigation accuracy category for position (NAC_P), navigation accuracy category for velocity (NAC_V), and indications of barometric altitude quality as defined in §3.3.1 through §3.3.1.

3.3.2.3.1.3 Future: Special Data

Planned final approach speed will need to be communicated to ASSAP from both own-ship and the lead-ship if the ASIA application is implemented. Planned final approach speed is the speed input to the ASIA application for the lead ship, and is an indicated airspeed.

3.3.2.3.2 Interfaces to ASSAP from TCAS

Future ASA systems will require TCAS RA information to support the ACM application.

For initial ASA applications, TCAS data is needed specifically to support configurations with integrated ASA / TCAS traffic displays[1]. For these configurations the data items in the following subparagraphs shall be provided to ASSAP for each TCAS track that is to be displayed. These items are required to allow the correlation of TCAS tracks with ASA tracks for traffic display integration, and these items also allow the display of an indication of an active Resolution Advisory (RA), or Traffic Advisory (TA).

3.3.2.3.2.1 RA Active

Indicates that a Resolution Advisory is currently in progress for the track.

3.3.2.3.2.2 TA Active

Indicates that a Traffic Advisory is currently in progress for the track.

3.3.2.3.2.3 Range

The range of the TCAS track from own-ship.

3.3.2.3.2.4 Bearing

The bearing of the TCAS track from ownship relative to the ship's heading.

3.3.2.3.2.5 Altitude

The barometric altitude of the track as reported by TCAS.

3.3.2.3.2.6 Altitude Rate

3.3.2.3.2.7 Mode S Address

The mode S address of the TCAS track.

3.3.2.3.2.8 TCAS Track ID

The internal track ID of the TCAS track.

3.3.2.3.3 Interfaces to ASSAP from Own-ship Navigation

3.3.2.3.3.1 Own-ship State Data

Own ship state data is defined identically to that of the target ship state data, as per §3.3.1.

[1] This display is sometimes termed the "TA" display.

3.3.2.3.3.2 Own Ship Quality

Own ship quality is very similar to target ship quality; however, as the information comes directly from the navigation system it is not yet categorized into NIC, NAC, and SIL values.

An integrity containment radius for position and associated no-alarm probability are assumed to be available from the navigation system. A 95% accuracy bound on both position and velocity are also assumed to be available. ASSAP shall provision for the acceptance of these parameters.

3.3.2.3.4 Flight Crew Inputs

A flight crew input may be required to display desired target parameters. For certain applications, the flight crew must select a specific target.

3.3.2.3.4.1 Selected Coupled Application

This is an indication of the application that is being run. Coupled applications include Enhanced visual approach, ASIA, and CSPA.

3.3.2.3.4.2 Selected Target

A selected target is a target for which a coupled application is to be conducted.

3.3.2.3.4.3 Alert Zone Selection

The alert zone specifies the horizontal and vertical criteria for a CD alert or ACM alert and resolution.

3.3.2.3.4.4 Future: Own-ship planned final approach speed

3.3.2.3.5 Future: Own-Ship ID

Own ship ID includes own-ship category that is needed for supporting the ASIA application. Both own-ship and lead-ship categories are needed to determine wake vortex separation minimums.

3.3.3 CDTI Subsystem Requirements

The requirements that these MASPS impose on the CDTI function may be categorized as follows:

- CDTI functional requirements (§3.3.3.1, starting on this page),
- CDTI performance requirements (§3.3.3.2, page 74), and
- CDTI interface requirements (§3.3.3.3, page 74).

3.3.3.1 CDTI Functional Requirements

Table 3.3.3.1 summarizes the minimum functional requirements on the receiving aircraft's CDTI function for each ASA level and, in the case of the Basic ASA level, for each Basic ASA level application. This table was derived from the table of CDTI requirements by application in Appendix B. << This assumes that such a table will exist in Appendix B! >> It differs from that table, however, in that the requirements are categorized by ASA level (§2.3) rather than by the needs of the individual applications as described in Appendices B to J.

Notes about Table 3.3.3.1:

1. *An "R" in a cell of the table indicates a minimum requirement for an installation to qualify for a particular ASA level, or, in the case of the Basic ASA level, a minimum requirement for a particular Basic application.*

2. *Likewise, an "ER" indicates an expected minimum requirement for the probing applications in the Advanced ASA level.*

3. *A "d" indicates a feature that is desirable for a particular application, but is not a minimum requirement of these MASPS.*

4. *The applications in the Basic ASA level do not require that other ASA participants should be notified that the own-ship participant is equipped for those applications. Indeed, Basic applications other than Enhanced Visual Acquisition (EV Acq) are optional. That is, an aircraft installation may be deemed to meet the requirements for the Basic ASA level without meeting the requirements for* all *Basic applications. This is why minimum requirements for the various Basic applications are called out in separate columns of Table 3.3.3-1.*

   For applications in higher ASA levels than Basic, however, a receiving ASA participant may need to know whether transmitting ASA participants have those applications installed. Also, for a participant aircraft to qualify for announcing that it supports one of the higher ASA levels (Intermediate, Advanced, etc.), it must meet the minimum requirements of all *of the applications in that category. (The rationale for this requirement is given in §2.3.) For this reason, the Intermediate or Advanced ASA levels are each represented by a single column in the table.*

5. *For reasons explained in §2.3, the ASA levels are arranged hierarchically. Thus, for example, any requirements on the CDTI for the Intermediate ASA level are also requirements for the Advanced category.*

Table 3.3.3.1: Summary of CDTI Functional Requirements

	ASA Level →		**Basic**				**Intermediate**	**Advanced**
	Applications →		Airborne		Surface			
	(See the section references for detailed requirements.) **Features ↓**	Section references ↓	EVAcq	CD	ASSA	FAROA	EV Approach	ACM ASIA ICSPA
Display Features (§3.3.3.1.1)	Standard Display Range, Map Scale	§3.3.3.1.1.1	R	R	R	R	R	R
	Reduced Display Range	§3.3.3.1.1.2			R	R		d
	Extended Display Range	§3.3.3.1.1.3						d
	Display Range / Map Scale Reference	§3.3.3.1.1.4	R	R	R	R	R	R
	Track-Up / Heading-Up Orientation	§3.3.3.1.1.5	R	R	d	d	R	R
	Aerodrome Surface Map	§3.3.3.1.1.6			R	R		
	Extended Runway Center Line	§3.3.3.1.1.7				R		ER
	Current ANSD Selection Indication	§3.3.3.1.1.8		R				ER
	Low Level Alert Selection Indication	§3.3.3.1.1.9		R				ER
	Recommended speed indication	§3.3.3.1.1.10						ER
Symbols (§3.3.3.1.2)	Own-Ship Symbol	§3.3.3.1.2.1	R	R	R	R	R	R
	Target Symbols – basic requirements	§3.3.3.1.2.2	R	R	R	R	R	R
	Target Symbols – variations	§3.3.3.1.2.3	d	d	d	d	R	R
	Selected traffic –more info	§3.3.3.1.2.3.3	d	d	d	d	R	R
	Selected traffic –coupled app.	§3.3.3.1.2.3.4					R	R
	Quality of Info (standard, degraded, non-directional)	§3.3.3.1.2.3.5	R	R	R	R	R	R
	Alerted Target Symbol	§3.3.3.1.2.3.6	d	d			d	R
Filtering	Traffic Display Criteria	§3.3.3.1.3	d	d	d	d	d	d
Info Required for Displaying All Traffic Targets (§3.3.3.1.4)	Time of Applicability of Target SV Data	§3.3.3.1.4.1	R	R	R	R	R	R
	Target ID (Flight ID / Call Sign)	§3.3.3.1.4.2		d	d	d	R	R
	Target Category	§3.3.3.1.4.3						
	Target Length/Width Codes	§3.3.3.1.4.4			d	d		
	Target Horizontal Position	§3.3.3.1.4.5	R	R	R	R	R	R
	Target Altitude (Relative or Actual)	§3.3.3.1.4.6	R	R			R	R
	Target Vertical Rate Indicator	§3.3.3.1.4.7		R				R
	Target Horizontal Velocity Vector	§3.3.3.1.4.8		d	d	d	R	R
	Target Heading	§3.3.3.1.4.9			R	R		ER
	Target Air/Ground Status	§3.3.3.1.4.10	R	R	R	R	R	R
	Target Qualification	§3.3.3.1.4.11		R				ER
Info for Selected Traffic Targets (§3.3.3.1.5)	Selected Target Highlighting	§3.3.3.1.5.1			d	d	R	R
	Selected Target ID	§3.3.3.1.5.2			d	d	R	R
	Selected Target Category	§3.3.3.1.5.3		d				R
	Selected Target Ground Speed	§3.3.3.1.5.4			d	d	R	R
	Selected Target Range	§3.3.3.1.5.5			d	d	R	R
	Selected Target Closure Rate	§3.3.3.1.5.6			d	d	R	R
	Off-Display Selected Target Bearing	§3.3.3.1.5.7						d
	Selected Target Qualification	§3.3.3.1.5.8					R	R
Alerting Elements (§3.3.3.1.6)	Alerted Traffic Symbol	§3.3.3.1.6.1	R	R			R	R
	Off-Display Alerted Traffic Bearing Indicator	§3.3.3.1.6.2	d	R	d	d		ER
	Application Alerts	§3.3.3.1.6.3	d	d			d	ER

3.3.3.1.1 CDTI Display Features

The CDTI **shall** display the position of traffic relative to own-ship when the traffic display criteria are satisfied.

When traffic display criteria (as defined in §3.3.3.1.3) are satisfied, the following features **shall** be continuously displayed, except when other filtering criteria (§3.3.3.1.3) are being applied:

- Own-ship symbol (§3.3.3.1.2.1);
- Traffic symbol (§3.3.3.1.2.2), shown at traffic 2D position (§3.3.3.1.4.2) relative to own-ship 2D position;
- Traffic altitude (§3.3.3.1.4.6);
- Range reference (§3.3.3.1.1.4);
- Traffic on-ground / in-air / unknown status (§3.3.3.1.4.10).

The requirements in the corresponding sub-sections **shall** be met for any feature that is implemented**.**

3.3.3.1.1.1 Standard CDTI Display Range (and Map Scale) Requirements

The terms "display range" and "map scale" have closely related, but slightly different, meanings. The CDTI *map scale* is an indication of the degree to which the display is zoomed in (or zoomed out) to show areas of smaller (or larger) geographical extent; it may be shown by a distance scale (e.g., a scale of nautical miles) on the CDTI display. The CDTI *display range* is the horizontal distance (in nautical miles or other appropriate units) between the own-ship position and the edge of the field of view on the CDTI display.

If the own-ship position is shown on the CDTI display, then the display range and the CDTI map scale are tightly coupled. Large map scales show areas of small geographical extent and have short display ranges. Small map scales show areas of large geographical extent and have longer display ranges.

It **shall** be possible for the flight crew to adjust the CDTI display range (and map scale).

The minimum CDTI display range **shall** be 10 NM or less in the direction of own-ship travel, from the own-ship position to the edge of the field of view on the CDTI display.

Note: *For future applications, a shorter range may be required.*

The maximum CDTI display range **shall** be 40 NM or more in the direction of own-ship travel, from the own-ship position to the edge of the field of view on the CDTI display.

If the CDTI function is implemented in a shared MFD, the display range and map scale of the CDTI function **shall** be the same as that of any other display functions that share the same MFD.

3.3.3.1.1.2 Reduced Display Range

A *reduced display range* is a display range that is shorter than the standard display range minimum of 10 NM.

For installations in which the ASSA or FAROA application is supported, the CDTI **shall** be capable of a reduced display range of 1.0 NM or less in the direction of own-ship travel, as measured from the own-ship position to the edge of the field of view on the CDTI display. (For such installations, lower ranges, such as 0.5 NM) may be useful or desirable.)

For installations in which the Independent Closely Spaced Parallel Approaches (ICSPA) application is supported, the CDTI **should** be capable of a reduced display range of 2 NM or less in the direction of own-ship travel, as measured from the own-ship position to the edge of the field of view on the CDTI display.

3.3.3.1.1.3 Extended Display Range

Extended display range capability is the capability of the CDTI to depict traffic at ranges up to at least 90 NM away from the own-ship in any direction.

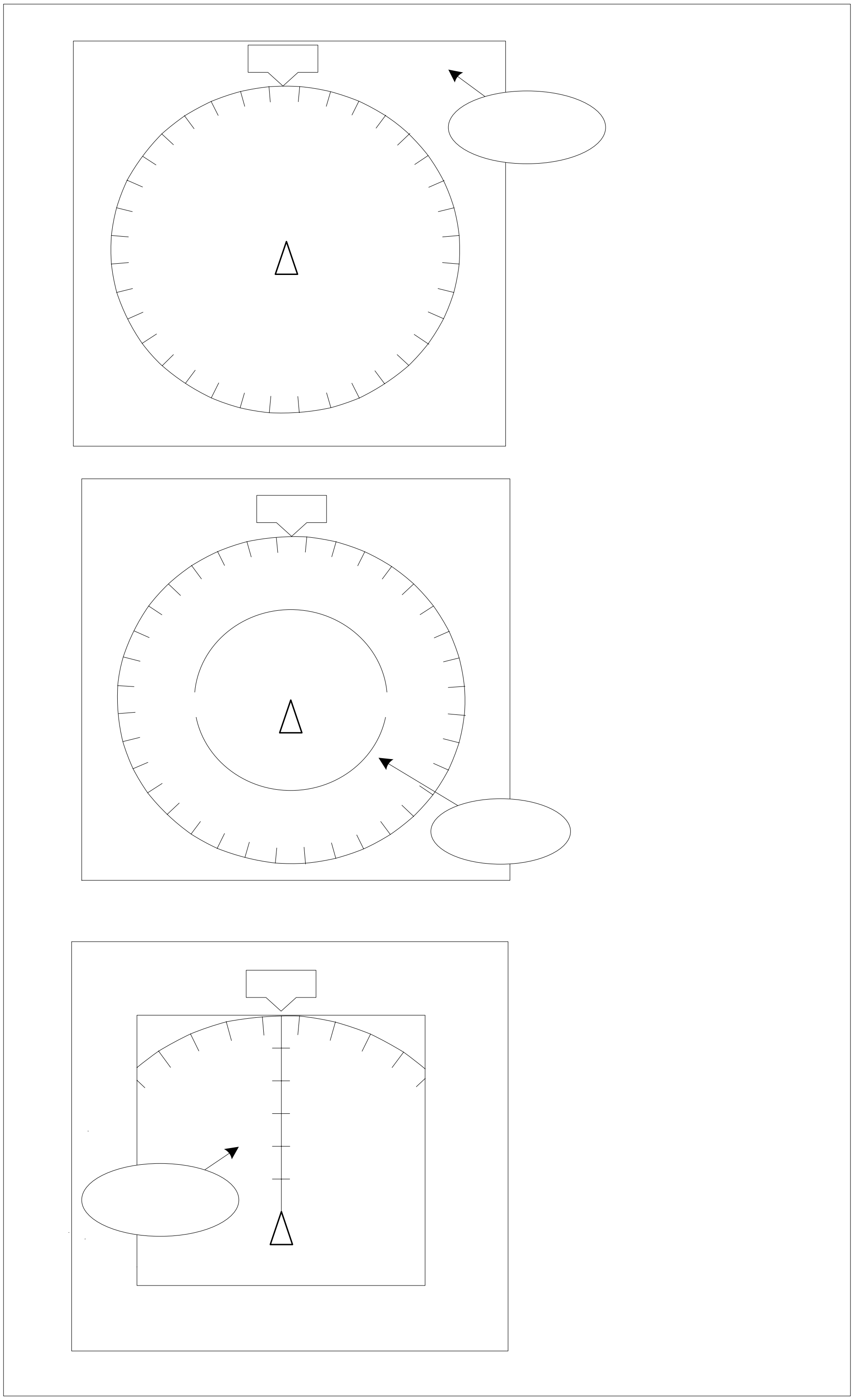
Note: *The extended display range capability is desirable for installations that support the Advanced ASA level, which includes the ACM application.*

3.3.3.1.1.4 Range Reference

The following requirements apply to all CDTI installations, regardless of the ASA levels that those installations support.

An indication of the currently selected CDTI display range or map scale **shall** be shown on the CDTI display. If traffic information is shown on a shared multifunction display (MFD) that does not provide a range reference (or map scale), then the range reference (or map scale) **shall** be shown whenever the MFD displays CDTI information.

Note: *These MASPS do not specify exactly* how *the display range (or map scale) is to be depicted on the CDTI display. Some alternatives (not the only possible alternatives!) are shown in Figure 3.3.3.1.1.4 below.*



<u>Figure 3.3.3.1.1.4</u>: Alternative Display Range and Map Scale Indications

3.3.3.1.1.5 Display Orientation

The CDTI **shall** be capable of orienting its display in at least one of the following ways:

Track Up: with the up (12 o'clock) direction on the display representing the direction of the own-ship ground velocity vector; or

Heading Up: with the up (12 o'clock) direction representing the direction towards which the nose of the aircraft points.

Notes:

1. *A "north up" display orientation mode may also be useful. In high latitudes, especially when in close proximity to the North or South Pole, a "grid north up" display orientation may be useful.*

2. *The track-up orientation requires an input to the CDTI function of the direction of the own-ship velocity vector. However, if that velocity vector has zero magnitude, then its direction is undefined. This can be an issue for surface applications such as Airport Surface Situational Awareness (ASSA) and Final Approach and Runway Occupancy Awareness (FAROA), as the own-ship may be stopped on the airport surface—or moving so slowly that the direction of its movement may be difficult to estimate.*

   Therefore, to support surface applications such as ASSA and FAROA, it is highly recommended that an own-ship heading input be provided to the CDTI so that a heading-up display can be provided, especially when the own-ship ground speed is low.

If the flight crew can select between more than one display orientation (e.g., "heading up", "ground track up", "true north up", "magnetic north up," "grid north up," etc.) then an indication of the current display orientation **shall** be continuously indicated to the flight crew.

A CDTI display that is configured to use the "track up" display orientation **shall** revert to the "heading up" orientation if ground track information becomes unavailable or of uncertain quality due to low ground speeds, and a source of own-ship heading information is available to the CDTI. For this reason, a CDTI installation that supports the Intermediate or Advanced ASA level **shall** (and an installation that supports only the Basic ASA level **should)** have a heading sensor installed on the own-ship aircraft.

Note 3: A fixed-wing aircraft installation that is configured to always use the "Track Up" orientation while in flight may nevertheless revert to a "Heading Up" display orientation when stopped on the surface. This should be permitted without requiring a notification to the flight crew, since in that circumstance heading is the best available estimate of the own-ship track angle.

Likewise, a CDTI display that is configured to use the "heading up" display orientation **should** revert to the track up" orientation if the own-ship heading information is lost or becomes invalid. When this happens, an indication of the loss of heading information **should** be provided, and the new display orientation **should** be indicated.

If both valid heading and valid track angle information are lost, an indication of that loss of own-ship directionality information **should** be provided to the flight crew; for CDTI installations that support the Intermediate or Advanced ASA Level, an indication of that loss of all own-ship directionality information **shall** be provided to the flight crew.

An indication of the value of the current own-ship CDTI display orientation (e.g., the value of the own-ship heading if in "heading up" mode, or the value of the own-ship track angle if in "track up" mode) **should** be continuously provided on the CDTI display. If such an indication is provided, and the own-ship directionality information becomes unavailable, an indication **shall** be provided to the flight crew that the CDTI display orientation value is no longer known.

Figure 3.3.3.1.1.5-A shows several ways that the display orientation might be indicated to the flight crew when the own-ship directionality information is available.

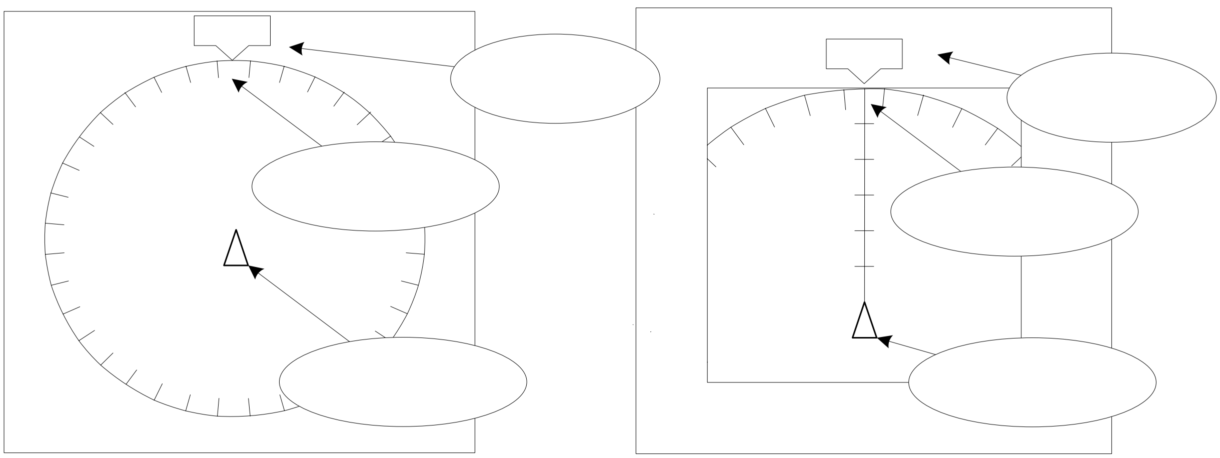


Figure 3.3.3.1.1.5-A: Display Orientation Indications (Normal Operation)

Figure 3.3.3.1.1.5-B shows some ways that display orientation might be indicated to the flight crew when own-ship directionality information is lost.

HDG 045 M

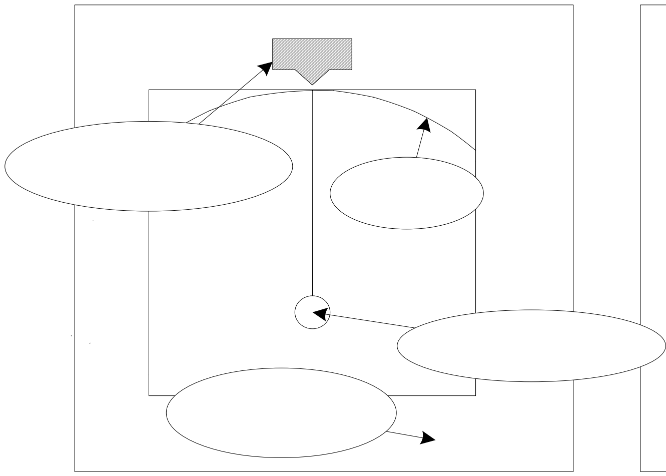


Figure 3.3.3.1.1.5-B: Display Orientation Indications (Loss of Own-Ship Directionality)

3.3.3.1.1.6 Aerodrome Surface Map

CDTI installations that support the Airport Surface Situational Awareness (ASSA) application **shall** provide a graphical depiction of the airport surface including runways and taxiways, and may include other features.

Notes:

1. *See [DO-272][2] for a listing and description of these features.*

2. *See [DO-257A] for the requirements of an aerodrome surface map.*

CDTI installations that support the Final Approach and Runway Occupancy Awareness (FAROA) application **shall** provide a graphical depiction of runways in the vicinity of the own-ship. This graphical depiction **shall** include the runway that the own-ship is occupying as well as any crossing runways. If the own-ship is not presently occupying a runway, but information is available about which runway it intends to occupy shortly, the graphical depiction of nearby runways **shall** include the runway that it is intended soon to occupy, as well as any crossing runways.

3.3.3.1.1.7 Extended Runway Center Line

An *extended runway center line* is defined as an extension outwards of the center line of a runway, from one or both ends of that runway.

CDTI installations that support the FAROA application (in the Basic ASA level) or that support the Advanced ASA level **shall** be capable of depicting extended runway center lines. The extended runway center line **shall** be distinguishable on the display from the runway itself.

[2] Items in brackets, such as [DO-272], are references to entries in the bibliography in Appendix B.

Notes:

1. *The actual depiction of the extended runway center lines might be triggered by commands or messages from the ASSAP function that is running application software for the FAROA, ASIA, or ICSPA application, or by pilot input.*

2. *It is permissible for both the extended runway center lines of each of an airport's runways to be depicted simultaneously. It is also permissible for the ASSAP function, if it has knowledge of which runway is active (or which runways are active) to command the CDTI function to show only the extended runway center lines of the active runway or runways.*

3. *It is permissible for the ASSAP function to command the CDTI to display runway center lines only when the FAROA, ASIA, or ICSPA application is active.*

Each extended runway center line, as depicted on the CDTI, **shall** extend to a distance of at least 5 NM from the end of the runway.

3.3.3.1.1.8 Assured Normal Separation Distance (ANSD) Selection Indication

The *assured normal separation distance* (ANSD) is defined as the normal minimum assured vertical and horizontal distances allowed between aircraft geometric centers.

Note: These distances are entered by the pilot or selected by the ASSAP function.

CDTI installations that support the Conflict Detection (CD) application in the Basic ASA level or that support the Advanced ASA level **shall** (a) provide for the display of the currently selected value of the ANSD and (b) accept pilot input of the ANSD value.

3.3.3.1.1.9 Low Level Alert Selection Indication

CDTI installations that support the Conflict Detection (CD) application in the Basic ASA level or that support the Advanced ASA level **shall** provide an indication as to whether the low-level alert is selected. The low-level alert feature is optional, and the selection and indication is only required if the feature is implemented.

Ed Note: -- need reference for low-level alert definition.

3.3.3.1.1.10 Recommended Speed Indication

The *recommended speed* is defined as the speed that the flight crew is recommended to fly. Recommended speed is an output from the ASSAP function that is provided when the Approach Spacing for Instrument Approaches (ASIA) application is active. CDTI installations that support the Advanced ASA level (which includes the ASIA application) **shall** be capable of displaying the recommended speed.

3.3.3.1.2 CDTI Symbols

If symbols are used to depict elements that have standard symbology (such as navigational fixes), the CDTI **should** use symbols that are consistent with established industry standards.

Note: Guidelines for electronic display symbology for navigation aids are provided in [SAE ARP5289].

3.3.3.1.2.1 Own-Ship Symbol

The traffic display **shall** have a symbol representing the location of the own-ship. The own-ship symbol **shall** be distinctive from all other symbology.

If directional data (e.g., own-ship heading, own-ship ground track angle) is available, the own-ship symbol **should** indicate directionality. If the own-ship symbol is directional, the front of the symbol that conveys directionality (e.g., apex of a chevron or nose of the aircraft if using an aircraft icon) **should** correspond to the aircraft location.

Note 1: The requirements and recommendations above are consistent with those of §2.3.1.2 of [DO-257A] for the depiction of the own-ship position on an Aerodrome Moving Map Display [AMMD].

If the map scale is sufficiently large (display range sufficiently small) that the dimensions of the own-ship aircraft are comparable, at the CDTI map scale, to the size of the own-ship symbol on the display, then the front of the directional own-ship symbol **should** correspond to the location of the nose of the own-ship aircraft.

Note 2: The above recommendation is more explicit than the corresponding recommendation in §2.3.1.2 of [DO-257A]. This more explicit recommendation, that the placement of the tip of the own-ship symbol should correspond to the location of the nose of the own-ship, is intended to support more demanding future CDTI applications, such a "blind taxi" application, in which it could be important to identify the horizontal extent of the own-ship and compare it with the horizontal extent of traffic targets on the same airport surface. This recommendation could become a requirement in a future version of these MOPS that supports the blind taxi application.

When using GNSS track angle for deriving own-ship directionality, if that directionality becomes unusable due to low taxi speeds or when stopped, the own-ship symbol **should** revert to a non-directional symbol (e.g., circle or regular polygon). If own-ship directionality information becomes unusable due to low taxi speeds or when stopped, then this condition **should** be indicated on the CDTI display. If the own-ship symbol is non-directional, the aircraft location **should** correspond to the center of the non-directional symbol.

Note 3: The recommendations above are consistent with those of §2.3.1.2 of [DO-257A] for the depiction of the own-ship position on an Aerodrome Moving Map Display [AMMD].

If the map scale is sufficiently large (display range sufficiently small) that the dimensions of the own-ship aircraft are comparable, at map scale, to the size of the icon that represents the own-ship, then the center of a non-directional own-ship symbol (e.g., circle or regular polygon) **should** correspond to the location of the center of the own-ship aircraft, that is, to a point on the centerline of own-ship that is half-way between the own-ship's forward and after extremities.

<u>Note 4</u>: *The above recommendation is more explicit than the corresponding recommendation in §2.3.1.2 of [DO-257A]. This more explicit recommendation is intended to support more demanding future CDTI applications, such a "blind taxi" application, in which it would be important to identify the horizontal extent of the own-ship and compare it with the horizontal extent of traffic targets on the same airport surface. This recommendation could become a requirement in a future version of these MOPS that supports the blind taxi application.*

If the CDTI supports more than one reference direction for the one own-ship symbol (e.g., heading vs. track), then the current own-ship symbol reference direction **shall** be indicated.

As long as valid own-ship directionality information (heading or track angle) is available, a directional own-ship symbol **shall** be used. If the display orientation is "heading up" or "track up," the own-ship symbol **shall** point up (representing own-ship heading if a "heading up" display, or own-ship track angle if a "track up" display). If another display orientation is used (e.g., "north up"), the orientation of the directional own-ship symbol **should** be correct with respect to that display orientation. If neither own-ship heading nor own-ship track angle is available, the CDTI **shall** indicate that fact. (e.g., "HDG LOST" or "TRK LOST" message, or own-ship symbol replaced with a non-directional symbol). If neither own-ship heading nor own-ship track angle is available, the own-ship symbol **should** be replaced with a non-directional symbol.

3.3.3.1.2.2 Basic Traffic Symbols (Directional and Non-Directional)

A *traffic symbol* is a depiction on the CDTI display of an aircraft or vehicle other than the own-ship. The following requirements and recommendations apply to all the traffic symbol variants listed in §0.

The CDTI **shall** display a traffic symbol for each traffic target about which the ASSAP function provides reports that meet the traffic display criteria. (See §3.3.3.1.3 below for a discussion of traffic display criteria.)

The CDTI **shall** position each traffic symbol at a location on its display representing the target's range and bearing with respect to the own-ship.

If valid directional data (i.e., ground track angle or heading) about a traffic target is available, the traffic target symbol **should** indicate directionality. If the traffic symbol is directional, the front of the symbol (e.g., apex of a chevron) **should** correspond to the target location.

The traffic symbol **shall not** imply specific directionality (that is, no sharply pointed traffic symbols like the arrowhead are to be used) if the directionality of the traffic target (ground track angle or heading) is unknown.

<u>Note 1</u>: *For example, the state vector report about an ADS-B surface participant would normally contain the participant's heading and a flag to indicate whether that heading is valid. If the flag indicates an invalid heading, then the traffic symbol representing that ADS-B participant should be a non-directional symbol.*

Airborne Targets. For each airborne target, the directionality of the target symbol in these requirements **shall** correspond to the ground track angle of that airborne target.

Note 2: The directionality of the traffic symbol for an airborne target is based on the ground track angle, not necessarily the heading, of that target. This is important for monitoring traffic, such as helicopters, that can fly backwards.

Surface Targets. For surface targets about which valid heading information is available, the directionality of the target symbol **should** correspond to the target heading.

Note: Surface targets that are ADS-B transmitting participants should be transmitting their headings, rather than ground track angles (See [DO-242A], §3.4.3.12.) Targets that are not being tracked by their ADS-B messages, however, will probably not have heading information available in the corresponding traffic reports from the ASSAP function.

For surface targets about which heading information is not available, and for which the ground track angle is not known to within an accuracy of ±15 <<TBD>> degrees, but for which the ground track angle is known to within an accuracy of ±45 <<TBD>> degrees, the degraded accuracy of the ground track angle **should** be indicated, possibly by means of a "degraded traffic" symbol (§3.3.3.1.2.3.5).

For surface targets about which heading information is not available, and that are stopped (zero ground speed), or that are moving so slowly that their ground track angles cannot be determined within an accuracy of ±45 <<TBD>> degrees, a non-directional traffic symbol **shall** be used.

It is, however, permitted to use the last known heading/track information for a duration of TBD seconds after the heading/track information stops becoming available. <<For discussion.>>

If the CDTI map scale is sufficiently large (CDTI display range sufficiently small) that the size of a surface target (as reported in the target's length and width codes) is comparable, at the CDTI map scale, to the size of the symbol depicting that target on the CDTI display, then the front of the directional target symbol (e.g., apex of a chevron) **should** correspond to the location of the front of the target A/V.

Note: The above recommendation is intended to support more demanding future CDTI applications, such a "blind taxi" application, in which it could be important to identify the horizontal extent of the own-ship and compare it with the horizontal extent of traffic targets on the airport surface. (In a future version of these MOPS, that supports the blind taxi application, this recommendation could become a requirement.)

Regardless of the CDTI display (map) orientation, traffic target symbols **shall** point in the direction of the target directionality (target track angle for airborne targets, target heading for surface targets) with respect to the display (map) orientation. Loss of own-ship heading or track angle **shall not** cause all traffic target symbols to change from directional symbols to non-directional symbols.

3.3.3.1.2.3 Traffic Symbol Variations

The depiction of traffic targets on the CDTI display **should** vary to convey the following information elements to the flight crew:

- The quality of the target data, especially with respect to the directionality of the traffic target: (a) standard directional target, (b) degraded directional target, or (c) non-directional target;
- The target's air/ground state: (a) airborne, or (b) on the surface;
- Whether or not the target has been selected, either (a) for the purpose of displaying more information about that target, or (b) for pairing with the own-ship in a particular *coupled application*; and
- Whether there is an alert with respect to the particular target: (a) no alert, (b) "caution" alert, or (c) "warning" alert.

With four parameters that can affect the depiction of a traffic target on the display, and with two of those being capable of assuming any of three values, and the remaining two capable of assuming either of 2 values, there are $3 \times 3 \times 2 \times 2 = 36$ possible combinations of these parameters. In order to manage the complexity of having as many as 36 distinct visual depictions of traffic targets, CDTI implementations **should** use different attributes of the symbol design to convey different attributes of the traffic targets. For example, the shape of a traffic target symbol might be used to convey one target attribute, while the presence or absence of an outline around a target symbol might convey a different attribute.

Note: *For example, target symbol shapes that are sharply pointed, or have blunt points, or are rounded might convey the target quality (standard quality, degraded quality, or non-directional). Likewise, the presence or absence of an outline around a target symbol might distinguish selected targets from those that have not been selected.*

3.3.3.1.2.3.1 Traffic Symbol Colors

Traffic symbols colored red **shall only** be used to indicate traffic targets for which there are "warnings," that is, alerts to which the flight crew must respond by taking immediate action. Traffic symbols colored amber or yellow **shall only** be used to indicate traffic targets for which there are "cautions," that is, alerts concerning which the flight crew may soon — but not necessarily immediately — have to take action. Other colors (i.e., not red, amber, or yellow) may be used to convey other target attributes.

Note: *The requirements in the preceding paragraph are consistent with those of [DO-257A], §2.1.6.*

3.3.3.1.2.3.2 TCAS Symbology

If the CDTI display is used not only as an ASA CDTI subsystem but also as a TCAS traffic display, then the symbology used for traffic targets that are the subject of TCAS surveillance **should** be compatible with the TCAS standard symbology described in §2.2.6.1.2.1.3 of [DO-185A].

3.3.3.1.2.3.2.1 TCAS-Only Targets

A *TCAS-only target* is a traffic target about which TCAS has provided surveillance information, but which the ASSAP function has not correlated with targets from other surveillance sources (such as ADS-B, TIS, or TIS-B).

TCAS-only targets **shall** be displayed using TCAS standard symbology (see §2.2.6.1.2.1.3 of [DO-185A]), as follows:

a. A TCAS-only target about which TCAS has declared an RA (Resolution Advisory) **shall** be displayed as a red filled square.
b. A TCAS-only target about which TCAS has declared a TA (Traffic Advisory) **shall** be displayed as an amber or yellow filled circle.
c. A TCAS-only target that TCAS has identified as Proximate Traffic **shall** be displayed as a white or cyan filled diamond.
d. A TCAS-only target that TCAS characterizes as Other Traffic (that is, not an RA, not a TA, and not Proximate Traffic) **shall** be displayed as a white or cyan diamond, outline only.

3.3.3.1.2.3.2.2 TCAS Targets That Are Correlated With Other Surveillance Sources

TCAS targets about which TCAS has declared a TA or an RA and that the ASSAP function has correlated with targets from other surveillance sources (such as ADS-B, TIS, or TIS-B) **should** be displayed using symbols that use elements of the TCAS standard symbology, but that also provide the target directionality or target data quality information available from non-TCAS surveillance sources. For example:

a. An ADS-B target that ASSAP has correlated with a TCAS Resolution Advisory might be displayed with a red outline square around the ADS-B target symbol, with the ADS-B target symbol shown in red.
b. An ADS-B target that ASSAP has correlated with a TCAS Traffic Advisory might be displayed with a yellow outline circle around the ADS-B target symbol, with the ADS-B target symbol shown in yellow.

TCAS targets about which TCAS has *not* declared an alert (TA or RA) and that the ASSAP function has correlated with targets from other surveillance sources (such as ADS-B, TIS, or TIS-B) need not be displayed using elements of the TCAS symbology. (Such targets are being provided by TCAS only for situational awareness, and there is no need to distinguish them from targets from other surveillance sources.) For example,

c. An ADS-B target that ASSAP has correlated with TCAS "Proximate Traffic" or "Other Traffic" might be displayed using only the ADS-B target symbol. Alternatively, it might be displayed with a white or cyan outline diamond around the ADS-B target symbol.

3.3.3.1.2.3.3 Selected Target Symbol

A *selected target* is a traffic target that the flight crew has designated as a target about which more information is to be displayed, usually in a *data block*: a region of the display that is outside the part of the display where traffic target symbols are shown and that shows additional information about a single target.

The CDTI display **shall** provide an indication of which specific traffic target, if any, has been designated by the flight crew as the selected target.

Note 1: *This information may be useful in performing a specific task related to that target.*

A *data tag* is shown within the part of display where traffic target symbols are shown, is located close to a particular traffic target symbol, and shows additional information about that symbol. (It is possible for multiple targets to have associated *data tags* shown next to their symbols, but there would generally be only one target for which information could be shown in a *data block*.)

Note 2: *Color has been successfully used primarily as an aid for visual search or for perceptual grouping. The use of color-coding has been found to reduce search times in densely populated displays when compared with performances obtained using size, shape, or brightness coding. (See [SAE ARP4102/4] and [DOT/FAA/AR-99/52], which provide display guidelines for color, size and brightness of symbols.)*

3.3.3.1.2.3.4 Coupled Selected Traffic Symbol

A *coupled selected target* is a specific aircraft or vehicle that the flight crew has designated, or that has been automatically designated by a crew-selected *coupled application*, so that the system can provide specific guidance and / or alerting relating to the coupled application.

In any CDTI installation that supports the Intermediate or Advanced ASA level, the CDTI display **shall** provide some means of distinguishing coupled selected traffic from traffic targets that are neither a *selected targets* (as described in §3.3.3.1.2.3.3) nor *coupled selected targets*.

It is not required by these MASPS that the symbols for coupled selected targets be distinguishable from those for selected targets. However, when the CDTI displays a selected target or a coupled selected target, an indication **should** be provided as to whether any selected target symbols being displayed have been selected as merely as targets about which the flight crew desires more information, or are coupled selected targets relating to a currently active coupled application.

3.3.3.1.2.3.5 Degraded Traffic Symbol

In any CDTI installation that supports the Intermediate or Advanced ASA level, the CDTI display **shall** provide an indication of which specific traffic targets are providing information of insufficient quality to support the currently selected coupled application. (See §1.3.7.2 or Appendix A for a definition of *coupled application*.)

Regardless of the ASA levels that they support, all CDTI installations **shall** provide an indication of which specific traffic targets provide information of insufficient quality to support any currently active *background applications*.

Note 1: *It is not required that the symbols for targets that provide data of insufficient quality for background applications should be distinguishable from the symbols for targets that provide data of insufficient quality to support the currently selected coupled application. It is permissible to use the same display symbol to represent both kinds of degraded quality traffic targets.*

Traffic targets for which directionality (i.e., ground track angle or heading) information is not available **shall not** **<<should not** ??>> be represented on the CDTI display with a symbol that conveys directionality, such as a sharply (or bluntly) pointed symbol.

Note 2: For example, an aircraft or vehicle that is not moving (undefined ground track angle) and that does not provide heading information should not be represented with a sharply pointed symbol such as an arrowhead or chevron. A non-directional symbol, such as a regular polygon, should be used to represent such a target on the CDTI.

3.3.3.1.2.3.6 Alerted Target Symbol

An *alert* is an indication that a developing situation needs the attention of the p9lot within an unspecified (but short) time interval, and has operational significance. Alerts include warnings, cautions, advisories, and other information of which the flight crew should be aware.

In any CDTI installation (a) that supports the CD application (in the Basic ASA level), or (b) that supports the Intermediate or Advanced ASA level, or (c) that is used as a TCAS traffic advisory display, the CDTI **shall** provide a symbol or symbols to depict a traffic target about which an *alert* is being presented.

3.3.3.1.3 Traffic Display Criteria

The CDTI function may <<**should**?? **shall**??>> include a traffic filtering capability by which the flight crew can cause the display not to show traffic targets that are not of interest or concern. For example:

- **Range Filtering.** By selecting a shorter display range (§3.3.3.1.1.1), the pilot could avoid displaying traffic targets that are relatively far away, and thus not of immediate interest. The shorter display range also implies a larger map scale, which would help to separate the symbols for targets that are close together.
- **Altitude Filtering.** By selecting a range of altitudes for targets to be displayed, the pilot could avoid displaying targets that are well separated from the own-ship altitude.
- **Air/Ground Filtering**. While airborne, the pilot could choose not to display targets that are known to be located on the surface.

Regardless of any traffic filtering which the flight crew may have selected, the CDTI **shall** indicate on the display any traffic targets for which the ASSAP function has determined that an alert (§3.3.3.1.6) is active.

Traffic filtering may be implemented entirely within the CDTI function, entirely within the ASSAP function, or partly within the CDTI function and partly within the ASSAP function.

Note: Just where traffic filtering is implemented is a matter of system design that is beyond the scope of these MASPS. If traffic filtering is implemented wholly or partially within the ASSAP function, then it will be necessary for the CDTI function to provide the ASSAP function with information from the CDTI control panel about which filtering limits the flight crew has selected.

3.3.3.1.4 Traffic Elements

The following subparagraphs state requirements about the information associated with *traffic*, i.e., aircraft or vehicles, other than the own-ship, which may be depicted on the CDTI display.

3.3.3.1.4.1 Time of Applicability of Target SV Data

The CDTI **should** show the positions of all traffic targets as of the same time of applicability.

Note: *Displaying the positions of different targets as of different times of applicability can confuse and distract the flight crew. This is especially so when the display is zoomed in to a short display range (large map scale).*

For example, consider two aircraft that are maintaining a constant distance and direction each from the other. If the positions on the CDTI display of the symbols for the two aircraft were to be updated independently as messages about those targets are received and provided to the ASSAP function, the relative positions of the target symbols on the CDTI display could change, even though the positions of the two aircraft with respect to each other would not be changing. This effect could annoy, confuse, or distract the flight crew observing the CDTI display.

3.3.3.1.4.2 Target Identification

Traffic Identification (Traffic ID) is a text representation of the flight ID or radio call sign used to identify a traffic target in voice communications with ATC. A traffic ID can consist of up to 8 characters selected from the capital letters, A to Z, and the numeric digits, 0 to 9.

Note 1: *For example, the aircraft called "United 912" in voice communications might be indicated on the CDTI display with a data tag of "UAL912," in which "UAL" means "United Air Lines" and "912" is the United Air Lines flight number.*

CDTI installations that support the Conflict Detection (CD) application or that support the Intermediate or Advanced ASA level **shall** be capable of depicting the identification (flight ID or call sign) of traffic targets. Such CDTI installations **shall** be capable of displaying traffic identifications of up to eight alphanumeric characters.

Note 2: *It is desirable that CDTI installations that support the ASSA, FAROA, and CD applications (in the Basic ASA level) should be capable of displaying the ID of traffic targets.*

Note 3: *Traffic identification may not be available for all traffic*

The traffic identification information **shall** be associated with the aircraft symbol.

Note 4: *The traffic identification may be displayed as part of a data tag, data block, or both data tag and data block.*

Ed Note: reference ADS-B MASPS and add to this MASPS.

3.3.3.1.4.3 Target Category

A *target category* (or *traffic category*) is a description of the type of aircraft, vehicle, or other ADS-B participant, as described in §2.1.2.2.3 of the ADS-B MASPS [DO-242A], where target categories are called "ADS-B emitter categories."

The CDTI is permitted, but not required by these MASPS, to display the target category of each traffic target that it displays, in a *data tag* near the symbol depicting the target on its display.

Note: *But see §3.3.3.1.5.3 below, where it is required that the CDTI be capable of displaying the target category of any target that has been designated as the* selected *target.*

The target category is also be used to determine the symbol used to depict the target on the CDTI display, as follows:

- Fixed or movable obstructions **shall** be depicted using a different symbol than the symbol or symbols used for aircraft and ground vehicles.
- Surface vehicles **should** be depicted using different symbols than those used for aircraft.

3.3.3.1.4.4 Target Length/Width Codes

It is desirable, but not required by this version of these MASPS, that a CDTI installation that supports surface applications (e.g., ASSA and FAROA) should accept aircraft/vehicle length and width codes and use them when depicting an aircraft or surface vehicle on the airport surface.

Note: *Future versions of these MASPS may require that length and width codes be used when depicting aircraft or surface vehicles on the airport surface. (The use of target length and width codes may be required for a future "blind taxi" application.)*

3.3.3.1.4.5 Target Horizontal Position

The CDTI **shall** accept horizontal position information (e.g., latitude and longitude, or range and bearing from own-ship) for each traffic target to be displayed and use that information to position the depictions of those targets on its display.

3.3.3.1.4.6 Target Altitude, Relative or Actual

CDTI installations:

a. that support the Enhanced Visual Acquisition or Conflict Detection applications (in the Basic ASA level), or

b. that support the Intermediate or Advanced ASA level

shall be capable of displaying the altitude (relative altitude or actual altitude) of traffic targets.

Altitude values **shall** be displayed for airborne traffic.

For traffic determined to be on the ground, an indication the traffic is on the ground **shall** be provided.

Altitudes for traffic simultaneously displayed **shall** be consistent, all altitudes being displayed either in actual or relative terms.

The CDTI **shall** be capable of displaying relative altitude.

If the CDTI is capable of displaying both relative altitude and actual altitude, the display **shall** indicate whether actual or relative altitude is displayed.

In addition to altitude value, the display **shall** indicate whether traffic is above or below own-ship.

> Note: *One method to indicate whether traffic is above or below own-ship is to show the traffic altitude value above or below the traffic symbol.*

If the traffic altitude is not available, the altitude information **shall not** be displayed.

If the traffic altitude is not available, an indication that it is not available should be displayed (e.g., NO ALT in the data tag).

The CDTI **should** be capable of displaying traffic within a minimum of ± 9900 feet of own-ship.

> Note: *Normally, flight crews are interested in traffic within a smaller altitude band. However, it is necessary under some circumstances for the crew to see traffic at much higher/lower altitudes (e.g., while climbing/descending).*

A capability to select an altitude band within which to display traffic **should** be provided to the flight crew. If that capability is provided, then the crew-selected altitude band **shall** be continuously displayed.

The traffic altitude value shall be displayed with a resolution of 100 feet or finer.

3.3.3.1.4.6.1 Relative Altitude

Relative altitude is the difference between own-ship and traffic altitude, calculated using the pressure altitude of both aircraft. The relative altitude of a traffic target is positive if that target is higher than the own-ship; it is negative if target is lower than own-ship.

If a numeric readout is used:

- The display of relative altitude shall consist of at least two digits indicating the altitude difference in hundreds of feet.
- For traffic above own-ship, the altitude value in the data tag **shall** be preceded by a plus sign (“+”) and be placed above the traffic symbol.
- For traffic below own-ship, the altitude value in the data tag **shall** be preceded by a minus sign (“-”) sign and be placed below the traffic symbol.

> Note: *The “+” or “–” character may be emphasized (e.g., by using a slightly larger character font than that used for digits).*

The data tag for co-altitude traffic (traffic at the same altitude as the own-ship) **shall** be displayed as the digits “00”.

<u>Note</u>: *The “+” or “–” tag may be retained with the “00” indication to denote that the system is in the relative altitude mode.*

The “00” characters **should** be placed above the traffic symbol if the traffic is closing from above; below the symbol if the traffic is closing from below.

If traffic is at co-altitude with own-ship and traffic is not climbing or descending at a rate greater than or equal to 500 fpm, the co-altitude “00” symbol **should** be placed below the traffic symbol.

3.3.3.1.4.6.2 Actual Altitude

Actual Altitude is the displayed altitude for traffic (when the actual altitude mode is selected) that is corrected for the local barometric pressure setting of the own-ship. Actual altitude may be uncorrected (i.e., pressure altitude) if the local barometric pressure setting of the own-ship is unavailable.

To display the actual altitude, the pressure altitude **should** be corrected for the local barometric pressure using the same correction used by the flight crew of own-ship.

An indication **should** be provided on the CDTI whether it is displaying the corrected or uncorrected value.

If the pressure altitude is not corrected for the local barometric pressure used by the crew of own-ship, the display of the actual altitude **shall** be limited to a maximum of 30 seconds if the own-ship is below 18,000 feet (transition altitude, if it is available, may be used instead of the 18,000 feet) before it automatically reverts to the relative altitude.

When the display of the actual altitude is selected, an indication that the displayed altitude is actual altitude **shall** be shown on the traffic display.

If implemented, the actual altitude **shall** be displayed as a three-digit numeral representing hundreds of feet, MSL. For example, 007 would represent 700 feet MSL, and 250 would represent 25,000 feet MSL.

<u>Note</u>: *Actual altitude may be positioned above or below the traffic symbol in a manner consistent with the relative altitude.*

3.3.3.1.4.7 Target Vertical Rate Indicator

The *vertical rate indicator* is an indication of whether the traffic aircraft is climbing or descending at a rate greater than a specified threshold. The vertical rate indication may be an up or down arrow.

CDTI installations that support the Conflict Detection (CD) application or that support the Advanced ASA level **shall** indicate a traffic target that is climbing or descending at a rate greater than 500 fpm.

<u>Note:</u> *TCAS uses a 500 fpm limit for this indication; therefore, this limit has been maintained for consistency with the TCAS user interface.*

3.3.3.1.4.8 Horizontal Velocity Vector

CDTI installations that support the Intermediate or Advanced ASA level **shall** be capable of depicting the magnitude and direction of the horizontal velocity of traffic targets. The traffic horizontal velocity **shall** be velocity with respect to the surface of the earth, or with respect to a coordinate system, such as WGS-84, that is fixed with respect to the surface of the earth.

Note: *It is desirable that CDTI installations that support the ASSA, FAROA, and CD applications should be capable of displaying the horizontal velocity of traffic targets.*

Traffic horizontal velocity vector information should be depicted graphically.

If the horizontal velocity vector is depicted in terms of time, the prediction time should remain the same regardless of the selected display range.

If the horizontal velocity vector is displayed for traffic, it should also be displayed for own-ship.

When horizontal velocity vector is displayed, units of measurement **shall** be the same between all displayed traffic and own-ship.

The units of the horizontal velocity vector should be displayed.

3.3.3.1.4.9 Heading

CDTI installations that support the ASSA and FAROA applications (in the Basic ASA level) and CDTI installations that support the Advanced ASA level **shall** be capable of indicating the heading of those traffic targets for which heading information is available. <<But see also requirements in §3.3.3.1.2.2. >>

3.3.3.1.4.10 Target On-Ground / In-Air / Unknown Status

CDTI installations that support the ASSA and FAROA applications (in the Basic ASA level) and CDTI installations that support the Advanced ASA level **shall** be capable of depicting the air/ground state (on ground, in air, or unknown) of traffic targets.

Note: *This requirement applies to all CDTI installations, regardless of the ASA levels supported by those installations.*

3.3.3.1.4.11 Target Qualification

ACM application. CDTI installations that support the Advanced ASA level **shall** be capable of depicting which traffic targets are capable of the ACM application.

CD application. CDTI installations that support the Conflict Detection (CD) application **shall** be capable of depicting whether or not traffic targets are capable of the CD application.

Note: *It is desirable that CDTI installations that support the Advanced ASA level should be capable of depicting which traffic targets are capable of the CD application.*

3.3.3.1.5 Selected Traffic Information and Features

A *selected target* is an aircraft or vehicle that the flight crew has selected, or that has been selected (by the flight crew or the ASSAP function) as a target of particular interest with respect to a *coupled application*. The following subparagraphs describe CDTI requirements concerning selected targets.

Note: *The definition of* coupled application *is given in §1.3.7.2 and also in Appendix A*

3.3.3.1.5.1 Highlighting of Selected Targets

CDTI installations that support the Intermediate or Advanced ASA level **shall** be capable of highlighting the depictions of selected targets.

Note: *It is desirable, that CDTI installations that support the ASSA and FAROA applications (in the Basic ASA level) should be capable of highlighting selected targets.*

<<Ed Note: coordinate with section §3.1.2. (basic & coupled target symbol)>>

3.3.3.1.5.2 Selected Target ID

CDTI installations that support the Intermediate or Advanced ASA level **shall** be capable of displaying the Traffic Identification (§3.3.3.1.4.2) of selected targets.

Notes:

1. *It is desirable that CDTI installations that support the ASSA and FAROA applications (in the Basic ASA level) should be capable of displaying the traffic identification of a selected target.*

2. *The selected target ID may be shown in a data tag next to the symbol for the selected target, or in a data block elsewhere on the display, or in both such places.*

3.3.3.1.5.3 Selected Target Category

A *target category* is a description of the type of aircraft, vehicle, or other ADS-B participant, as described in §2.1.2.2.3 of the ADS-B MASPS [DO-242A], where target categories are called "ADS-B emitter categories."

CDTI installations that support the Advanced ASA level **shall** be capable of displaying the target category of the selected target.

Notes:

1. *It is desirable that CDTI installations that support the Conflict Detection (CD) application (in the Basic ASA level) should be capable of displaying the category of a selected target.*

2. *The selected target category may be shown in a data tag next to the symbol for the selected target, or in a data block elsewhere on the display, or in both such places.*

3.3.3.1.5.4 Selected Target Ground Speed

CDTI installations that support the Intermediate or Advanced ASA level **shall** be capable of displaying the ground speed of the selected target.

The traffic display should be capable of displaying selected target ground speeds up to at least 999 knots.

An indication **shall** be displayed if the selected ground speed exceeds the indicator limit.

Selected target ground speed **shall** be distinguishable from other information.

If numerical ground speed is displayed as knots, the unit of measure is not required to be displayed. If alternative units (i.e., anything other than knots) are used, the unit of measure of ground speed **shall** be displayed.

If numerical ground speed is displayed, it **shall** be shown with a resolution of 1 knot or finer.

3.3.3.1.5.5 Selected Target Range

The *selected target range* is the distance of that target from the own-ship. It is normally expressed in nautical miles (NM).

CDTI installations that support the Intermediate or Advanced ASA level **shall** be capable of displaying the range from own-ship of the selected target.

Note: *It is desirable that CDTI installations that support the ASSA and FAROA applications (in the Basic ASA level) should be capable of displaying the selected target range.*

3.3.3.1.5.6 Selected Target Closure Rate

The *range rate* and *closure rate* of a selected target are both rates of change of the range from own-ship to that target is changing. Range rate is positive if the range to the target is increasing, and negative if the range rate is decreasing. Closure rate, however, has the opposite sense: it is positive if the range is decreasing and negative if the range is increasing.

CDTI installations that support the Intermediate or Advanced ASA levels **shall** be capable of displaying the closure rate of the selected target.

When closure rate is displayed, it may be displayed either graphically or alphanumerically.

A positive closure rate (traffic getting closer) **shall** be distinguishable from a negative closure rate (traffic getting farther away).

Closure rate information **shall** be distinguishable from other information about the selected target.

Note: *Since the closure rate and relative altitude both have positive and negative values, they may be confused with each other if provisions are not made to distinguish between them.*

If numerical closure rate is displayed in knots, the unit of measure (knots) need not be displayed. If alternative units (i.e., anything other than knots) are used, the unit of measure **shall** be displayed.

If a numerical closure rate is displayed, the CDTI **shall** be capable of displaying it with a resolution of 1 knot or finer.

If the CDTI is capable of displaying both horizontal-only (two-dimensional) and horizontal and vertical (three-dimensional) closure rate, then the selected method **shall** be displayed to the pilot.

The traffic display should be capable of showing closure rates up to at least ±99 knots.

An indication should be displayed when the maximum closure rate display capability of the CDTI is exceeded.

3.3.3.1.5.7 Off-Display Selected Traffic Bearing

The *off-display selected target bearing* is an indication on the CDTI to the flight crew of the position of a selected traffic that is outside of the selected display range.

If the selected target is beyond the currently selected display range, an indicator **shall** show the bearing of the selected target from the own-ship.

Note: *The selected target could be beyond the display range if a target is selected and then the display range or scale is changed. This could also occur, more gradually, if a target is selected and then the range to that target increases until the target is further from the own-ship than the currently selected display range.*

For CDTI installations that support *only* the enhanced visual acquisition (EVAcq) application (in the Basic ASA level), the off-display selected traffic bearing **shall** be shown with an accuracy of ±15 degrees or better.

For all other CDTI installations, the off-display selected traffic bearing **shall** be shown with an accuracy of 3 degrees or better.

3.3.3.1.5.8 Selected Target Qualification Indicator

An indication to the flight crew on which traffic is capable or not capable of any operating application.

3.3.3.1.6 Alerts

For more details on the alerting applicable to a specific application see the application description in the corresponding application appendix. (Appendices B to J are the application appendices.)

Traffic alerting (a generic term) is a mechanism that attracts the attention of the pilot to a traffic situation. Implementation of alerting is recommended and should be considered by the manufacturer. Though alerting is not required for the surveillance operational applications on which many of the MOPS requirements are based, it is considered beneficial based on initial operational evaluations. This subsection provides requirements and guidance that apply if alerting is implemented. (Also see notes under the Traffic Symbol section).

Alerting may be implemented in a variety of ways (e.g., aural, visual, tactile). Alerting should be integrated with a spatial presentation of the traffic. For example, with a plan view CDTI format, the specific aircraft involved in generating the alert may be highlighted and the projected point of closest approach may also be highlighted. In addition, the alerting may also be displayed on a separate section of a CDTI outside of the area dedicated for traffic information.

Note 1: *The requirements in this subsection apply only if the CDTI presents alerts.*

7. CDTI alerting should not interfere with other alerting systems.

8. Alerts should be consistent with the flight deck alerting system and philosophy.

9. For those flight decks that utilize an integrated alerting system, the CDTI should be integrated into that system.

10. When alerts are enabled, they **shall** be annunciated without flight crew action.

11. If alerts are disabled by the pilot, the system alert status **shall** indicate that alerts are disabled.

12. CDTI alerts should be consistent with, and capable of being integrated into the flight deck alerting system, giving proper priority to alerts with regard to safety of flight.

13. Non-critical alerts **shall** be inhibited during critical phases of flight (e.g., take-off and landing).

14. Aural alerts **shall** be audible in all expected flight deck ambient noise conditions.

15. Voice alerts **shall** be announced in a high fidelity, distinguishable voice.

16. Symbology or text indicating an alert should be redundantly coded by at least two different coding parameters (e.g., color, size, shape, location).

17. The color of the annunciations should conform to recommendations in SAE ARP 4102/4[4] reference J information (level 0) or advisory (level 1) annunciation, as appropriate

Note 2: *Automatic volume adjustment for ambient conditions is highly recommended. The TCAS MOPS [DO-185A] recommends that the volume level of the automatic adjustment provide a range of 0 to 4 watts RMS at 1000 Hz into 8 Ω for a speaker output and the automatic adjustment provide a range of 0 to 40 mW at 1000 Hz into a 600 Ω audio distribution system.*

3.3.3.1.6.1 Alerted Traffic Symbol

The *alerted traffic symbol* is an indication on the CDTI display of which traffic target is causing an alert.

1. CDTI installations that support the Conflict Detection (CD) application in the Basic ASA level, or that support the Intermediate or Advanced ASA level **shall** be provide some means, such as a distinct alerted traffic symbol, of distinguishing the traffic target that is that is causing an alert from traffic targets represented on the CDTI display.

2. If a CDTI function is to be used with an ASSAP function that provides an (optional) *proximity alert* feature for use with the Enhanced Visual Acquisition (EVAcq) application, then that CDTI function **shall** provide a means, such as an alerted traffic symbol, by which the flight crew can identify the particular traffic target or targets causing a proximity alert.

3.3.3.1.6.2 Off-Display Alerted Traffic Bearing Indicator

An *off-display alerted traffic bearing indicator* is an indication to the flight crew of the direction (bearing from own-ship) of any traffic target that is the cause of an alert and is beyond the field of view of the CDTI display.

1. CDTI installations that support the CD application (in the Basic ASA level) or that support the Advanced ASA level **shall** provide off-display alerted traffic bearing indicator.

2. If an off-display alerted traffic bearing indicator is available for airborne applications, it should be available for surface applications (e.g., ASSA and FAROA) also.

3.3.3.1.6.3 Application Alerts

It is desirable, but not required by these MASPS, that a CDTI installation that supports the Basic or Intermediate ASA level should be capable of displaying alerts to the flight crew. However, CDTI installations that support the Advanced ASA level **shall** be capable of displaying alerts to the flight crew.

EV Acquisition, EV Approach: If the pilot is unable to include the CDTI as part of the normal instrument scan, an alert may be required to inform the pilot of the desire to view the CDTI or the need to look out the window. At the time of writing of these MASPS, however, an alert has not been identified as a minimum requirement for a CDTI to support the Enhanced Visual Acquisition (EVAcq) or Enhanced Visual Approach (EVApp) application.

Approach Spacing for Instrument Approaches (ASIA): An ASIA alert is an alert that warns the flight crew if (a) the spacing to nearby traffic is less than a distance or time set by the flight crew, or (b) if the ASSAP function predicts that the required spacing over the threshold cannot be maintained. CDTI installations that support the Advanced ASA level **shall** provide a means of alerting the flight crew when the ASSAP function detects an ASIA alert.

Airborne Conflict Management (ACM): Alerts associated with Conflict Detection, Conflict Prevention, and Conflict Resolution. These include Low Level, CDZ, and CAZ conflict detection alerts, Low Level and CDZ conflict prevention alerts, and Low Level, CDZ, and CAZ maneuver advisories. In a CD only or full ACM system, Low level (if implemented), CDZ level, and CAZ level alerts must alert the crew to the appropriate conflicts. In a full ACM system Low level (if implemented) and CDZ level conflict prevention alerts must alert the crew to any maneuver that could result in a conflict. In a full ACM system, associated with and of the conflict alerts are maneuver advisories that will resolve any conflicts.

Closely Spaced Parallel Approaches (ICSPA): CDTI installations that support the Advanced ASA level **shall** be capable of alerting the flight crew when the ASSAP function detects an alert related to Advanced applications (e.g., ICSPA)

<<Ed Note: add definition of the alerts supporting ICSPA.>>

<<Own ship deviation (2 levels)>>

<<Traffic (2 levels)>>

Notes:

1. *If these features are available for airborne applications, they should be available for ground application also.*

3.3.3.2 CDTI Performance Requirements

<<Need to provide text describing performance requirements for the CDTI subsystem.>>

3.3.3.3 CDTI Interface Requirements

The CDTI provides surveillance information to the flight crew, and receives input commands from the flight crew. The information provided to the flight crew may be of many forms. For example, information may be interfaced on one or more displays, such as the primary flight display and the navigation display. The information provided to the crew may also consist of aural alerting, for example. Inputs from the crew can consist of key presses, for example, to highlight or select a particular target for additional information, for initiation of a cooperative operation, or for mode selection and output target filter parameters (e.g., display range).

It is expected that the CDTI will ultimately integrate data and alarms from other sources of information beyond surveillance processing, such as weather, terrain, etc., but these additional data sources and their integration are beyond the scope of this draft of the ASA MASPS.

3.3.3.3.1 CDTI Inputs from ASSAP

Table 3.3.3.3.1 summarizes the required inputs to the CDTI from ASSAP. The table groups the requirements by ASA level (§3.2) and, in the case of the Basic ASA level, by the needs of the various Basic applications. An "R" in a cell of the table indicates a required input at the ASSAP-to-CDTI interface requirement to qualify for a particular ASA level, or in the base of the Basic ASA level, a minimum requirement for a particular Basic application. Likewise, a "d" indicates an input from the ASSAP function that is desirable for a particular ASA level (or Basic application), but is not a minimum requirement of these MASPS.

The section reference for each row of the table points to the subparagraph where the requirement is stated explicitly and in more detail.

Table 3.3.3.3.1: Summary of Required CDTI Inputs from the ASSAP Function

Input Category	Inputs ↓	Section references ↓	EVAcq	CD	ASSA	FAROA	EVApp	ACM, ASIA, ICSPA
		ASA levels →	**Basic**				**Intermediate**	**Advanced**
		Applications →	Airborne		Surface			
ID (§3.3.3.3.1.1)	ASSAP Track ID	§3.3.3.3.1.1.1	R	R	R	R	R	R
	Traffic ID (call sign / flight ID)	§3.3.3.3.1.1.2	d	d	d	d	R	R
	Target Category	§3.3.3.3.1.1.3	d	d	d	d	R	R
	A/V Length / Width Codes	§3.3.3.3.1.1.4			d	d		
Target State (§3.3.3.3.1.2)	Time of Applicability	§3.3.3.3.1.2.1	R	R	R	R	R	R
	Horizontal Position	§3.3.3.3.1.2.2	R	R	R	R	R	R
	Horizontal Velocity	§3.3.3.3.1.2.3	R	R			R	R
	Pressure Altitude	§3.3.3.3.1.2.4	R	R			R	R
	Geometric Altitude	§3.3.3.3.1.2.5						
	Vertical Velocity	§	R	R			R	R
	Surface/Airborne Indication	§	R	R	R	R	R	R
	Heading	§			R	R		
Target Quality (§3.3.3.3.1.3)	Qualify for background applications?	§3.3.3.3.1.3.1	R	R	R	R	R	R
	Qualify for coupled application?	§3.3.3.3.1.3.2					R	R
TCAS (§)	RA in progress (notes 1 to 4)		R	R			R	R
	TA in progress (notes 1 to 4)		R	R			R	R
ASA Alerts and Advisories (§)	Associated Track ID			R			R	R
	CAZ alert			R			R	R
	CDZ alert			R			R	R
	(Future) ACM advisory							R
	(Future) ICSPA" track" level 1							R
	(Future) ICSPA "track" level 2							R
	(Future) ICSPA "traffic"							R
	(Future) ICSPA system failure alert							R
	(Future) ICSPA "breakout" alert							R
	(Future) ASIA longitudinal separation alert							R
	(Future) ACM system failure alert							R
ASA Guidance (§)	(Future) ASIA commanded speed							R

Notes for Table 3.3.3.3.1:

1. *Required if TCAS is present in the configuration and an integrated TCAS traffic display and CDTI is used. Future systems with ACM will require the RA indication regardless of whether the TCAS display and CDTI are integrated.*

2. *TCAS TA and RA information for the traffic display is forwarded through ASSAP. Vertical guidance is provided from TCAS directly to the appropriate vertical speed indication and is outside the scope of ASA, as indicated in TBD.*

3. *The flight crew will see only one displayed position for one aircraft/vehicle on a display where TCAS and ASA targets are both displayed but this does not preclude separate displays for TCAS and ASA. The TCAS alert shall be applied to this one position whether or not the TCAS data is the displayed position.*

4. *The position for the traffic display that is shown to the flight crew shall be provided by ASSAP.*

3.3.3.3.1.1 Identification Inputs

3.3.3.3.1.1.1 ASSAP Track ID

The *ASSAP track ID* is a unique identifier from ASSAP to the CDTI that identifies the traffic target for which data is being provided. The CDTI interface from ASSAP **shall** accept ASSAP track IDs from the ASSAP function.

3.3.3.3.1.1.2 Traffic Identification

Traffic identification (traffic ID) is the flight ID or radio call sign by which a traffic target is identified. It can consist of up to eight alphanumeric characters, as specified in §3.3.3.1.4.2 above.

Any CDTI installation that supports the Conflict Detection (CD) application (in the Basic ASA level) or that supports the Intermediate or Advanced ASA level **shall** accept traffic ID for each traffic target about which the ASSAP function provides traffic ID information. It is desirable, but not a minimum requirement of these MASPS, that a CDTI installation that supports only Basic applications other than the CD application should also accept traffic ID information from the ASSAP function.

Any ASSAP function that supports the CD application or that supports the Intermediate or Advanced ASA level **shall** provide traffic ID information to the CDTI for each traffic target about which it has traffic ID information. It is desirable, but not a minimum requirement of these MASPS, that an ASSAP function that supports only Basic applications other than the CD application should provide traffic ID information to the CDTI for each traffic target about which it has traffic ID information.

Note: *Requirements on how the CDTI uses Traffic ID are found in §3.3.3.1.4.2 above.*

3.3.3.3.1.1.3 Target Category

A *target category* (or *traffic category*) is a description of the type of aircraft, vehicle, or other ADS-B participant, as described in §2.1.2.2.3 of the ADS-B MASPS [DO-242A], where target categories are called "ADS-B emitter categories."

In any CDTI installation that supports the Intermediate or Advanced ASA level, the CDTI **shall** accept target category information from the ASSAP function for any traffic targets for which the ASSAP function provides that information. It is desirable, but not required by these MASPS, that a CDTI installation that supports only the Basic ASA level should accept target category information from the ASSAP function.

Any ASSAP function that supports the Intermediate or Advanced ASA level **shall** provide target category information to the CDTI for each traffic target for which the CDTI function has that information. It is desirable, but not required by these MASPS, that an ASSAP function that supports only the Basic ASA level should provide the CDTI with target category information for all traffic targets about which it has that information.

3.3.3.3.1.1.4 A/V Length /Width Codes

Any CDTI installation that supports the ASSA or FAROA application **shall** accept A/V length and width code information about any traffic targets for which the ASSAP function provides that information.

Any ASSAP function that supports the Intermediate or Advanced ASA level **shall** provide the CDTI with the A/V length/width code information about any traffic targets regarding which the ASSAP function has that information – at least while the ASSA or FAROA application is active.

3.3.3.3.1.2 Target State Information

Target state information is information about a traffic target's position, velocity, heading, etc.

3.3.3.3.1.2.1 Time of Applicability of Target State Information

3.3.3.3.1.2.2 Target Horizontal Position

The CDTI uses horizontal position information about traffic targets to place the icons representing those targets at appropriate locations on its display.

The CDTI function **shall** accept horizontal position information about each traffic target for which the ASSAP function provides that information.

Note: *Horizontal position information need not be provided to the CDTI as WGS-84 latitude and longitude. It might, for example, be provided as range and bearing from the own-ship position. If a traffic target's horizontal position is provided as range and bearing (r, θ), the target bearing might be relative to the own-ship heading, relative to the own-ship ground track angle, or even relative to true or magnetic north. These details are left to the designers of the ASSAP-to-CDTI interface.*

The ASSAP function **shall** provide horizontal position information about each traffic target.

3.3.3.3.1.2.3 Target Horizontal Velocity

The CDTI uses horizontal velocity information about traffic targets in order to display their horizontal velocity vectors as specified in §3.3.3.1.4.8 above.

In installations that support the Intermediate and Advanced ASA levels, the CDTI function **shall** accept horizontal velocity information about each traffic target for which the ASSAP function provides that information. In such installations, the ASSAP function **shall** provide the CDTI function with horizontal velocity information about each traffic target. The traffic horizontal velocity **shall** be velocity with respect to the surface of the earth, or with respect to a coordinate system, such as WGS-84, that is fixed with respect to the surface of the earth.

<u>Note</u>: *A traffic target's horizontal velocity may be expressed using either Cartesian coordinates (e.g., north and east velocity components) or polar coordinates (e.g., ground speed and track angle). The decision as to which representation is to be used is left to the designers of the ASSAP-to-CDTI interface.*

3.3.3.3.1.2.4 Target Pressure Altitude

The CDTI function **shall** accept pressure altitude information about each airborne traffic target for which the ASSAP function provides that information. This may be either (a) the relative pressure altitude of each traffic target with respect to own-ship, i.e., target altitude minus own-ship altitude, or (b) the pressure altitude of the traffic target *and* the pressure altitude of the own-ship.

The ASSAP function **shall** provide the CDTI function with pressure altitude information about each airborne traffic target for which it has that information. Again, this may be either (a) the relative pressure altitude of the target with respect to own-ship pressure altitude, or (b) the pressure altitude of the traffic target *and* the pressure altitude of the own-ship.

<u>Note</u>: *These MASPS do not specify in which of the two alternative forms the pressure altitude of traffic targets is to be provided (actual pressure altitude or pressure altitude relative to own-ship pressure altitude). That question is left for the designers of the ASSAP-to-CDTI interface to decide.*

3.3.3.3.1.2.5 Target Geometric Altitude

3.3.3.3.1.3 Target Quality Information

At the ASSAP-to-CDTI interface, the *target quality* information indicates for which applications a particular traffic target qualifies.

3.3.3.3.1.3.1 Qualification for Background Applications

Target qualification indicates the background application(s) that can be supported for the indicated target. Target qualification must be communicated between ASSAP and the CDTI for CD and ACM. All targets sent from ASSAP to the CDTI shall be qualified, at a minimum, for service level 0, i.e., they must support EV Acquisition for airborne targets, and ASSA and FAROA for surface targets.

Table 3.3-10: Target Qualification for Background Applications

Target Qualification	In-flight	Surface
0	EVAcq, FAROA	ASSA, FAROA
1	CD	Future
2	ACM	Future
3	ICSPA	Future

ASSAP shall provide the highest possible level of applications processing for qualified targets for applications that are active. E.g., if ACM is running, and a target is qualified for ACM, then ACM processing must be provided for that target.

3.3.3.3.1.3.2 Target Qualification for Coupled Applications

Coupled applications are specifically selected via CDTI controls. For each target that is provided to the CDTI, an indication shall be provided of whether or not that target that is suitable for use with the currently selected coupled application.

3.3.3.3.2 CDTI Inputs from TCAS

An indication shall be provided to the CDTI that a particular ASSAP track currently has a TCAS resolution advisory or traffic advisory.

3.3.3.3.3 ASA Alerts and Advisories

Alerts shall be provided to the CDTI with an appropriate indication of the associated track. Alerts specific to future applications may be required in future editions of this MASPS. For this version of the MASPS CAZ and CDZ alerts shall be distinguished by ASSAP.

3.3.3.3.4 Future: Guidance

Guidance will be necessary for the ASIA application, which will provide an indicated air speed for the flight crew to follow. It may be preferable to present the speed guidance on the primary flight display.

3.3.3.4 << CDTI Parking Lot>>

<<The following subsections do not belong to this part of these MASPS (§3.3.3) and are only retained in this file temporarily, until we are assured that another home for them has been found.>>

3.3.3.4.1 Future: Interfaces to TCAS

Future ADS-B applications such as ICSPA will require that certain tracks be suspended from consideration for resolution advisories. A list of these tracks will need to be supplied to TCAS. Table 3-11 specifies future interfaces to TCAS.

Note: *ADS-B systems may interface directly to TCAS and will communicate position data and ICAO address (for hybrid surveillance). The requirements for hybrid surveillance are outside of the scope of this MASPS.*

<u>Table 3.3-11:</u> (Future) Interfaces *to* TCAS

	Data Element	From Subsystem	EV Acquisition	EV Approach	ASSA	FAROA	ASIA	CD	ACM	ICSPA
ID	TCAS Track ID	ASSAP		1.						•
	Address	ASSAP								•
ICSPA Special	Suppress RA									•

• *= Required; d = desired*

3.3.3.4.2 Future: Flight Management System Interfaces

ASSAP may interface with FMS equipment. For example, if an impending unsafe situation as determined by ACM requires a change to a waypoint, the flight management system would have to be notified and the waypoint change entered. Examples of data from ASSAP to FMS are 4-D flight path change, are waypoint changes, and speed commands. And examples of data interfaced from the FMS to ASSAP are waypoints.

3.3.3.4.3 Future: Flight Control systems (autopilot or auto-throttle):

Surveillance processing may interface with Flight control systems. For example, a separation assurance application may require a speed command that could be coupled to the autopilot or auto-throttle. ASIA is one candidate application for this type of interface, although it has not been determined that this is required.

3.3.3.4.4 Future: Addressed Communications

Future pair-wise applications may require an exchange of addressed information with other aircraft required for specific applications, excluding ADS-B on-condition reports.

3.4 External Subsystems

Subsystems external to ASA include navigation, TCAS, flight management and flight controls, etc.

The ASA MASPS does not specify requirements on these subsystems, but assumptions regarding external subsystem performance are listed.

3.4.1 Navigation

The navigation subsystem is assumed to produce the following values:

- State data (§ **Error! Reference source not found.**)
- Time of applicability (§ **Error! Reference source not found.**)
- Horizontal Position (§ **Error! Reference source not found.**)
- Horizontal Velocity (§ **Error! Reference source not found.**)
- Altitude (§ **Error! Reference source not found.**)
- Altitude rate (§ **Error! Reference source not found.**)
- Surface / airborne indication (§)
- Heading (§ **Error! Reference source not found.**)
- Navigation information quality (§ **Error! Reference source not found.**)

3.4.2 TCAS

<<add requirements here>>

3.4.3 Airport Surface Maps

<<add requirements here>>

3.4.4 Flight Management System

<<add requirements here>>

3.4.5 Flight Control System

<<add requirements here>>

3.4.6 FIS-B / Weather

<<add requirements here>>

3.4.7 Terrain

<<add requirements here>>

3.4.8 Addressed Data Link

<<add requirements here>>

3.4.9 ADS-Contract

<<add requirements here>>